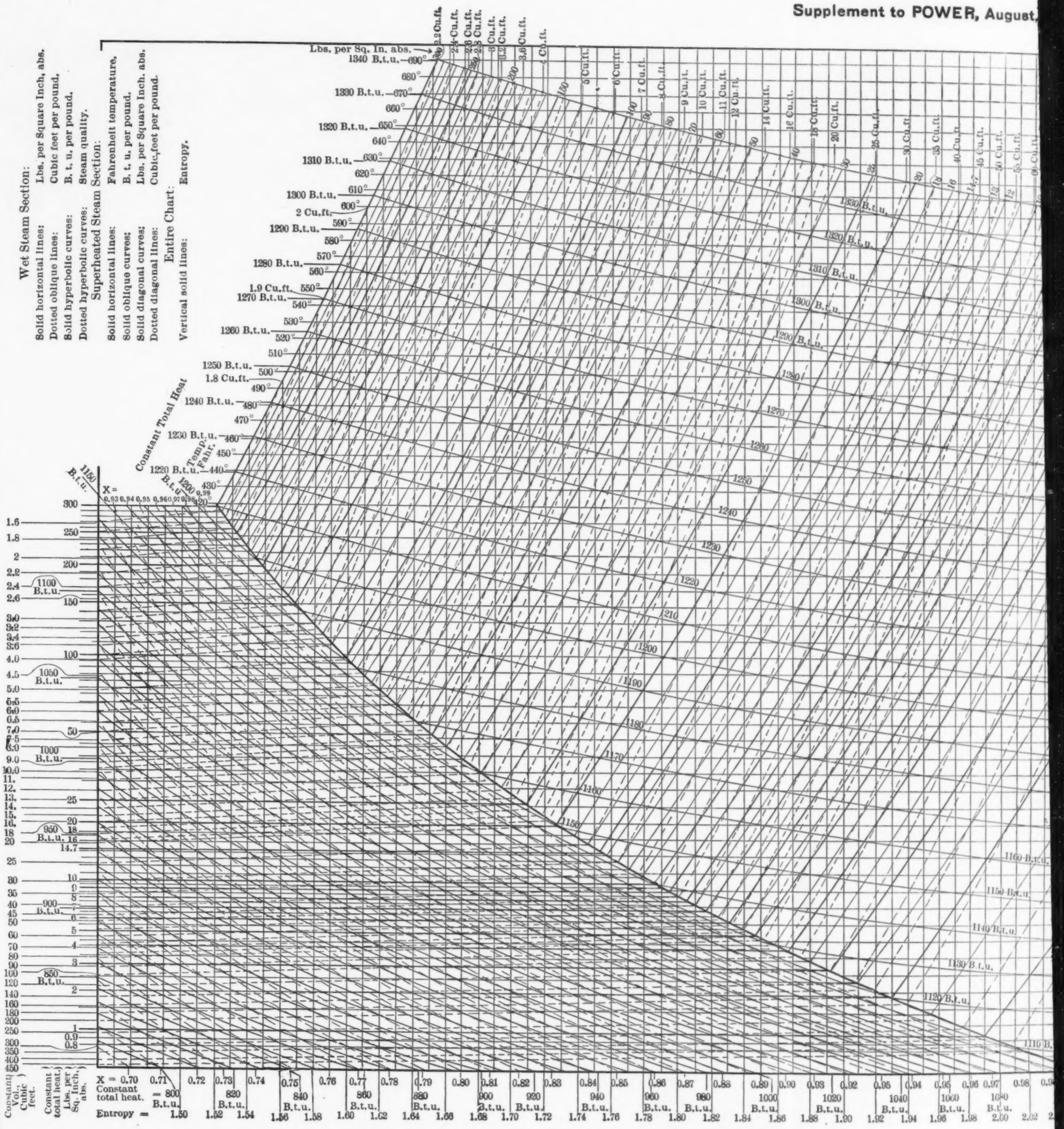
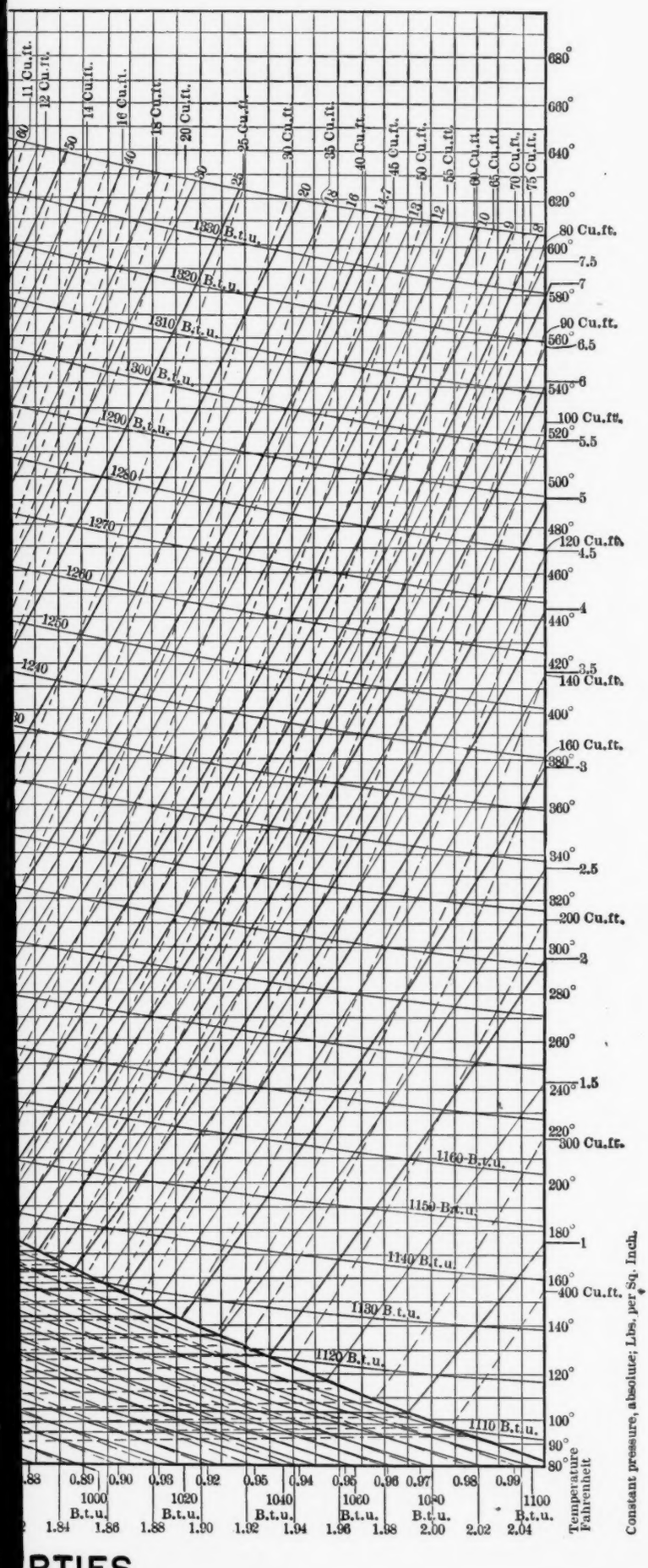
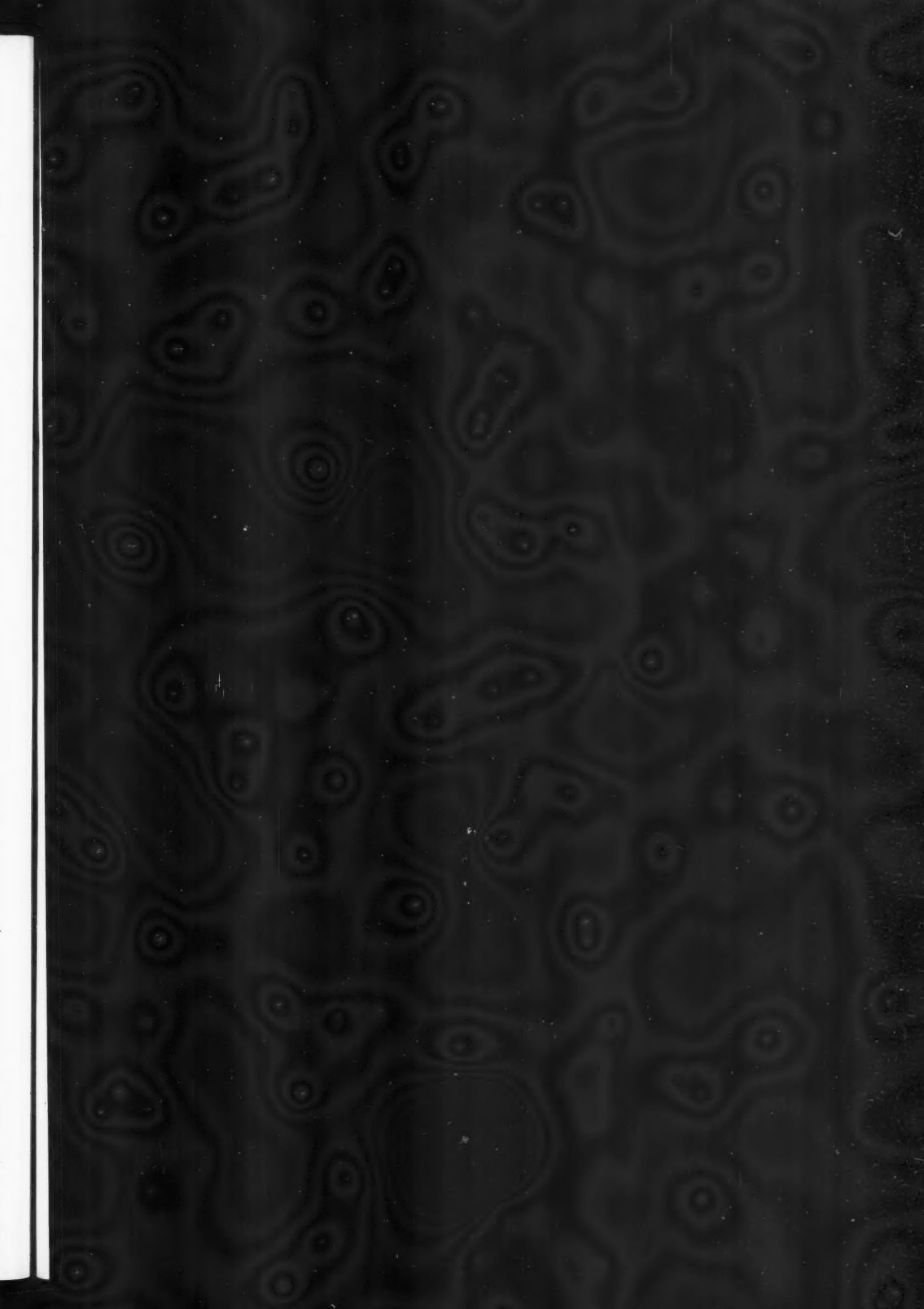

Wet Steam Section:
Solid horizontal lines: Lbs. per Square Inch, abs.
Dotted oblique lines: Cubic feet per pound.
Solid hyperbolic curves: B. t. u. per pound.
Dotted hyperbolic curves: Steam quality.
Superheated Steam Section:
Solid horizontal lines: Fahrenheit temperature.
Solid oblique curves: B. t. u. per pound.
Solid diagonal curves: Lbs. per Square Inch. abs.
Dotted diagonal lines: Cubic feet per pound.
Entire Chart:
Vertical solid lines: Entropy.
Lbs. per Sq. In. abs.
Constant Total Heat
Temp. Fahr.
X = 0.93 0.94 0.95 0.96 0.97 0.98 0.99
Constant Vol., Cubic feet.
Constant total heat, Lbs. per Sq. Inch. abs.
X = 0.70
Constant total heat. = 800 B.t.u.
Entropy = 1.50

DIAGRAM OF STEAM PROPERTIES.


11 Cu.ft.
12 Cu.ft.
14 Cu.ft.
16 Cu.ft.
18 Cu.ft.
20 Cu.ft.
25 Cu.ft.
30 Cu.ft.
35 Cu.ft.
40 Cu.ft.
45 Cu.ft.
50 Cu.ft.
55 Cu.ft.
60 Cu.ft.
65 Cu.ft.
70 Cu.ft.
75 Cu.ft.
1330 B.t.u.
1320 B.t.u.
1310 B.t.u.
1300 B.t.u.
1290 B.t.u.
1280
1270
1260
1250
1240
1160 B.t.u.
1150 B.t.u.
1140 B.t.u.
1130 B.t.u.
1120 B.t.u.
1110 B.t.u.
680°
660°
640°
620°
80 Cu.ft.
600°
7.5
580°
7
90 Cu.ft.
560°
6.5
540°
6
100 Cu.ft.
520°
5.5
500°
5
480°
120 Cu.ft.
4.5
460°
440°
4
420°
3.5
140 Cu.ft.
400°
160 Cu.ft.
380°
3
360°
340°
2.5
320°
200 Cu.ft.
300°
3
280°
260°
240°
1.5
220°
300 Cu.ft.
200°
180°
1
160°
400 Cu.ft.
140°
120°
100°
90°
80°
0.88
0.89
0.90
0.91
0.92
0.93
0.94
0.95
0.96
0.97
0.98
0.99
1000 B.t.u.
1020 B.t.u.
1040 B.t.u.
1060 B.t.u.
1080 B.t.u.
1100 B.t.u.
1.84
1.86
1.88
1.90
1.92
1.94
1.96
1.98
2.00
2.02
2.04
Temperature Fahrenheit
Constant pressure, absolute; Lbs. per Sq. Inch.

RTIES.



There have been suggestions that the specific heat of superheated steam is not constant, but increases with an increase of temperature; but since there are no reliable data on this subject, however, and no general law of variation of the specific heat has been given, the assumption must suffice that it remains constant until conclusive information on the subject is made public.

The curves on the diagram corresponding to *Y-Z-Z* and *V-W-W* in Fig. 1, are lines of constant total heat and are simply drawn through all points on the diagram which have the same total heat above the freezing point. Since the total heat remains constant along these lines, they represent also all points on the entropy-temperature diagram which have the same area, and consequently if we pass from any line of constant total heat to another by way of an adiabatic, the difference between the total heat at the beginning and that at the end of the expansion or compression will represent the difference in area of the diagram in British thermal units.

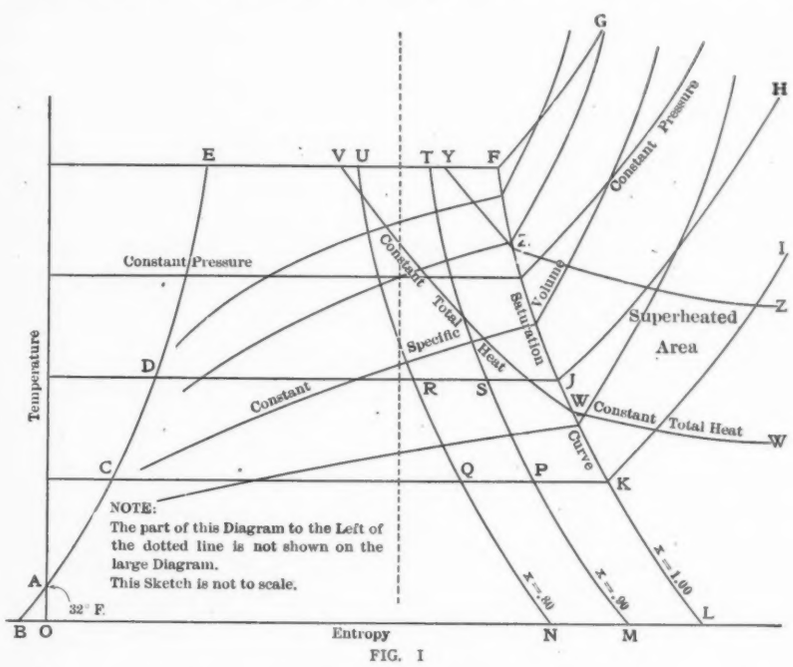


FIG. 1

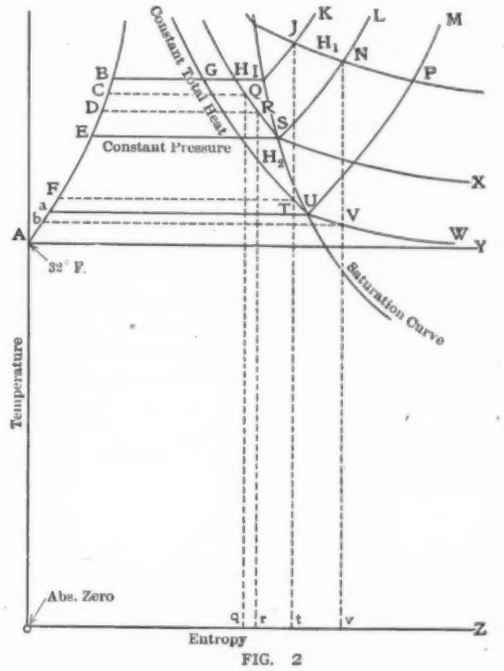


FIG. 2

The last proposition is probably made clearer by Fig. 2, in which the lines *A-E-B* and *I-S-U* are the entropy of water and the saturation curves respectively; *B-I-K*, *E-S-L* and *a-U-M* are lines of constant pressure, and *J-N-P*, *H-S-X* and *G-U-W* are lines of constant total heat. The total heat above the freezing point of the point *J* is represented by the area *O-A-B-I-J-t-O* and in the same manner the heat at *N* is represented by the area *O-A-E-S-N-v-O*. In the "moist" portion, in a similar way, the heat at *Q* is represented by the area *O-A-C-Q-q-O*, and so on. Now, if the heat at *N* and that at *J* are equal, the areas *O-A-B-I-J-t-O* and *O-A-E-S-N-v-O* must be equal, and hence no work is done if the fluid follows the curve *J-N*, etc. Now if the expansion, say from *J* (total heat H_1) to *T* follows the adiabatic *J-t*, the heat at *T* being H_2, it follows that the work done will be represented by the difference between the areas *O-A-B-I-J-t-O* and *O-A-F-T-t-O*; expressed in heat units it will be $H_1 - H_2$ B.t.u.; in other words the difference between the total heats at two points is equal to the work done during the cycle. It will be noted that *O* is at the absolute zero and *A* at 32 degrees Fahrenheit (493 Fahrenheit degrees, absolute) and entropy is figured from zero at *A*. The work done in foot-pounds per pound of steam will be 778 times the difference in the total heat between the two points.

The curves of constant heat were calculated by the formula

$$t = \frac{H - 1116\,x + k}{1 - 0.71\,x},$$

in which t is the temperature, x the quality of the steam, H the total heat of the curve being calculated and k a quantity obtained from the steam table. As the specific heat of water is not constant at all temperatures, t was calculated approximately by letting $k = 32$ B.t.u.; when the approximate value of t had been found, the value of k for that temperature was found from the steam tables, and with the more exact value of k the final temperature was obtained by a second approximation, which was found to be sufficiently exact.

In the superheat area, $H = H_s + c_p(t' - t)$ from which

$$t' = t + \frac{H - H_s}{0.48}.$$

In these equations H is the total heat being calculated, Hs is the total heat of saturated steam at a temperature t as found in the steam table; this locates a point on each of the constant-pressure curves in the superheated area by the intersection of the pressure lines with the lines of constant temperature; t' is the temperature of the superheated steam.

The application of the diagram may be best understood by following through a few examples.

Condition of Saturated Steam at a Given Temperature

Find the absolute pressure, total heat, specific volume and entropy of saturated steam at 350 degrees Fahrenheit.

The absolute pressure (135 pounds) may be read from a steam table, or by following the 350-degree line across from the right-hand side of the diagram. On the scale at the left-hand margin of the "wet" portion of the diagram find 135; trace along this horizontal line to the curve of saturated steam, which separates the wet and superheated parts of the diagram; the 350-degree line intersects this curve slightly below a point midway between the two dotted lines marked 3.2 and 3.4, so that the specific volume is slightly more than 3.3 cubic feet per pound.

The intersection at the saturated-steam line is somewhat above the point midway between the solid lines representing 1180 and 1190 B.t.u. total heat, so that by interpolation the total heat would be read about 1188 B.t.u.

Now following down the vertical line which meets the horizontal pressure line at the saturated-steam curve, the scale at the bottom of the diagram, by estimation, gives the entropy as 1.576.

Work Done by Superheated Steam Expanded Adiabatically

Find the final condition of steam that has been expanded adiabatically to a pressure of 5 pounds absolute from a pressure

of 190 pounds absolute, the steam having been originally superheated to 650 degrees.

Starting at the intersection of the saturated-steam curve and the 190-pound pressure curve, follow the latter up to where it intersects with the horizontal line corresponding to 650 degrees on the temperature scale. This intersection occurs at a point between the diagonals 1320 and 1330 of the total-heat curves which corresponds to 1328 B.t.u. Since adiabatic expansion is a special case in which entropy remains constant, the entropy of the steam at the end of expansion is the same as before it begins. Following down the vertical line which intersects with the 190-pound curve and the 650-degree line, the entropy is found to be 1.685; tracing back up the entropy line to its intersection with the 5-pound pressure line it will be found that the total heat is about 1033 B. t.u., and the quality 90 per cent. The work done by the expansion is obviously the difference between the initial heat of 1328 B.t.u. and the final heat of 1033 B.t.u. or 295 B.t.u., which is equivalent to 229,510 foot-pounds of work.

Steam Required Per Horse-power-hour

Having found the work equivalent of the adiabatic expansion of one pound of steam under given conditions, the quantity of steam theoretically required per hour to develop one horse-power is readily determined. In the last preceding example, under the conditions stated, a pound of steam expanded adiabatically represented 229,510 foot-pounds. One horse-power is the equivalent of 1,980,000 foot-pounds per hour; consequently an ideal engine expanding steam under the conditions stated would require

$$\frac{1,980,000}{229,510} = 8.627$$

pounds of steam per hour. Of course, this last calculation could be made on the basis of heat units instead of foot-pounds, thereby avoiding the conversion. The work in heat units was 295 B.t.u., and a horse-power is equivalent to 2545 B.t.u. per hour; hence the ideal engine would require $2545 \div 295 = 8.627$ pounds of steam per hour.

Point at Which Superheated Steam Becomes Saturated by Expansion

Suppose that it is desired to ascertain at what pressure superheated steam, expanding from an initial pressure of 190 pounds and 650 degrees, becomes saturated. Follow down the vertical line which crosses the intersection of the 190-pound curve and 650-degree line until the saturated steam curve is reached; then trace to the left parallel to the nearest horizontal pressure line to the vertical scale on the margin; by interpolation the pressure is found to be 31½ pounds absolute.

Dividing the Work of Expansion Equally between Two or More Cylinders or Stages

Suppose the work done in adiabatic expansion from 190 pounds and 650 degrees to 5 pounds is to be divided equally between three cylinders or turbine stages. It was shown that the total work was 295 B.t.u., and if the cylinders or stages are to do equal parts of it, each must do one-third, equivalent to 98.333 B.t.u. The total heat before expansion was found to be 1328 B.t.u., and if 98.333 B.t.u. are used in the first cylinder it will leave 1229.67 B.t.u., in the steam at the end of its period of expansion. Follow down the entropy line which cuts the 190-pound and 650-degree intersection until the point is reached where the entropy line would cut the 1229.67 heat line if the curves were drawn closely enough to give a line for that point of the scale. As nearly as the diagram can be read by this interpolation, the constant-pressure curve which would cut this intersection would be that corresponding to 74 pounds absolute pressure. The heat remaining in the steam after the second expansion would be $1229.67 - 98.33 = 1131.33$ B.t.u. and the pressure line (in the moist steam part of the diagram) which would meet the entropy line at the point corresponding to this total heat if the lines were closely drawn, would give 22 pounds absolute as the terminal pressure of the steam. The terminal pressure of the three cylinders or stages, therefore, would be 74, 22 and 5 pounds successively.

To Find the Condition of Steam after Throttling

A further property of these curves will become evident when it is remembered that when a gas or vapor expands without doing external work, the heat energy of the gas remains unchanged, and, since this is the condition of "throttling" or "wire-drawing" the steam, all the blue lines of "Constant Total Heat" are throttling lines. Hence, it is possible without calculation to see just what happens when steam at any pressure and condition of moisture or superheat is throttled to some lower pressure. Suppose, for example, it is desired to find the condition of the steam after it had been throttled down from 210 pounds absolute to 100 pounds absolute, supposing the steam was dry at the start. Since the heat remains constant, follow the heat line passing through the saturation curve at its intersection with the 210-pound pressure curve to where it cuts the 100-pound pressure curve; the temperature line cutting this intersection shows the steam to be at 367½ degrees, and as the temperature of saturated steam is 327½ at 100 pounds, the sample contains about 40 degrees of superheat; its specific volume is 4.75 cubic feet per pound. If the initial quality of the steam had been 96 per cent., instead of following the total heat curve passing through the intersection of the 210-pound pressure curve and the saturated-steam curve, we would follow the interpolated heat curve passing through the intersection of the 210-pound pressure line and the 0.96 quality curve, and where this heat curve cuts the 100-pound line is the deciding point. Following this out, we find the condition of the steam to be $x = 0.983$, volume $= 4.35$ cubic feet per pound, entropy $= 1.58$.

Quality of Steam from a Throttling Calorimeter

The diagram is also useful in obtaining the moisture in steam by use of the throttling calorimeter and there should be no difficulty in correctly obtaining the moisture in steam to within one-tenth of one per cent., which is sufficiently accurate for most purposes. For example, a throttling calorimeter attached to a boiler showing 120 pounds gage pressure exhausts into the atmosphere (14.7 degrees absolute nearly) and thermometer on the calorimeter indicates 219.5 degrees Fahrenheit; find the percentage of moisture in the steam. This is done by following an interpolated heat curve which cuts the intersection of the atmospheric-pressure line and the 219.5-degree line (in the superheat part of the diagram) back to where it crosses the interpolated pressure line corresponding to $(120 + 14.7) = 134.7$ pounds absolute, where the quality is found by the diagram to be, $x = 0.955$; hence the moisture is 4.5 per cent.

Design of Nozzles for Impulse Turbines Taking into Account the Losses by Friction

In the designing of nozzles for steam turbines, these curves will enable the designer to make proper allowances for the frictional and eddy losses in the nozzles, both of which have the effect of making the area at the mouth of the nozzle and the nozzle ratio too small if the nozzle is constructed according to theory with these losses neglected. The reason for this is that the velocity at the mouth is less than theory demands, and the volumes of the steam somewhat large, since the heat lost in friction and eddies tends either to superheat the steam, or, if moist, to re-evaporate some of the moisture, either of which processes increases the volume of steam which must pass through the mouth of the nozzle. This application of the diagram will be discussed in a later article on turbine design.

On September 1 the American Museum of Safety Devices and Industrial Hygiene of the American Institute of Social Service, William H. Tolman director, will remove to the third floor of the new Thirty-ninth Street Building, between Seventh and Eighth avenues, New York City.

The Hydraulic Elevator—VIII

Principal Causes of Disordered Mechanism and How Prevented or Removed; Directions for Packing the Pistons and Valves

BY WILLIAM BAXTER, JR.

The hydraulic elevator, like every other type of machine, must be kept in perfect order to give satisfactory results. Some of the effects produced by a disordered condition of the mechanism can be easily detected; in fact, they make themselves conspicuous by causing the elevator car to run erratically. Other defects, however, can be discovered only by careful inspection of the entire apparatus. Disorders of the first-named kind do not as a rule, produce any permanent injury or deterioration of the running parts, and are of necessity soon rectified; hence, they are not as serious as those of the second type, whose only effect is to deteriorate the apparatus. The principal disorders which produce noticeable effects are leaks in the lifting-cylinder piston, the stuffing-boxes and the valves. These cause the car to settle slowly after being stopped.

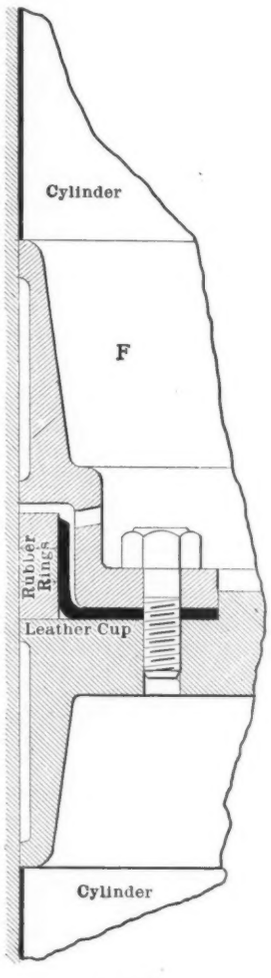


FIG. 71

Sometimes the car bounces up and down a number of times when stopping, especially if a sudden stop is made. This action, however, is not produced by an actual defect in any part of the apparatus as a general rule, but is more likely due to an accumulation of air in the lifting cylinder. This air, being elastic, will compress in the act of stopping, on a downward trip of the car, and will expand on an upward trip, owing to the fact that the momentum of the car and other moving parts resists the stopping, thus increasing the pressure within the cylinder on the downward trip and reducing it on the upward trip. After the valve has been closed the momentum of the moving parts is fully absorbed either by compressing the air to a pressure greater than is necessary to balance the load, or by expanding it to a lower pressure. As a result, in the first case the extra pressure of the air will force the piston down and lift the car, while in the second case the piston will move upward to compress the air to the balancing point, and the car will run down.

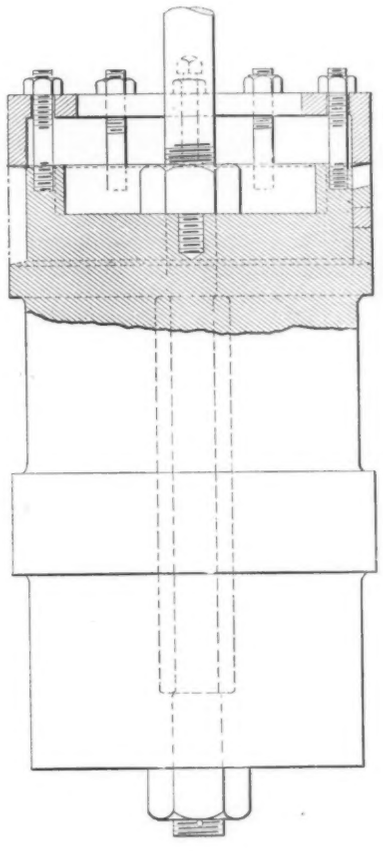


FIG. 72

Owing to the elasticity of the air, the expansion and compression will be repeated several times, imparting to the car a teetering motion which is supposed by many people to be produced by the stretching and contracting of the lifting ropes. As this teeter effect is far more noticeable in high buildings, the belief that it is due to the elasticity of the ropes is strengthened; but as a matter of fact the explanation is that in high buildings the car speed is much greater; therefore, the stops are necessarily more sudden and the momentum of the moving parts produces a greater expansion or compression of the air confined in the cylinder.

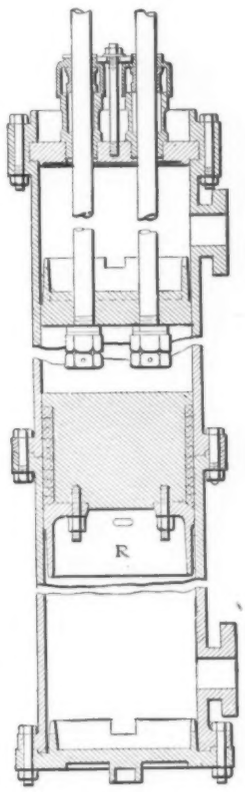


FIG. 73

Theoretically, stretching of the lifting ropes actually takes place every time the car is stopped, but although ropes when very lightly loaded will elongate considerably with a slight increase in weight, when strained to even 5 or 6 per cent. of their ultimate strength they will not stretch much more than solid rods, so that the rise and fall of a car due to the stretching of the ropes is probably not

more than a small fraction of an inch, even for a length of two hundred feet, or more.

The accumulation of air in the lifting cylinder is not due to a disordered condition of the apparatus, but to some extent it may be excessive on account of improper arrangement or proportions of the discharge and pressure tanks. All water contains air in very small bubbles, the amount being greater when the water is agitated than when it is at rest. If the pressure is increased the bubbles come together and form a smaller number of larger size, with increased buoyancy, and so the air is "squeezed" out of the water. If the water is compressed into a tank where it can remain quiet for a time, considerable air will be forced out of it. It therefore follows that with a large pressure tank less air will pass into the cylinder than with a small one, but the difference is hardly enough to warrant the use of an extra large tank for this reason alone, and it is seldom taken into account by designers of elevator installations.

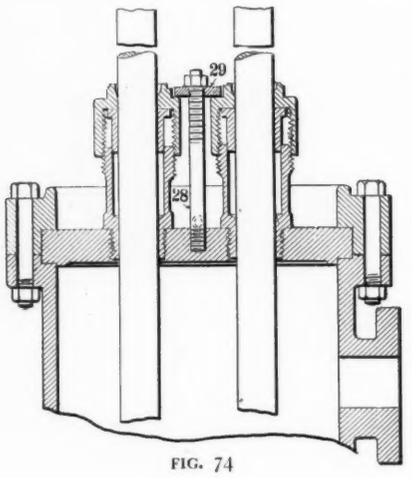


FIG. 74

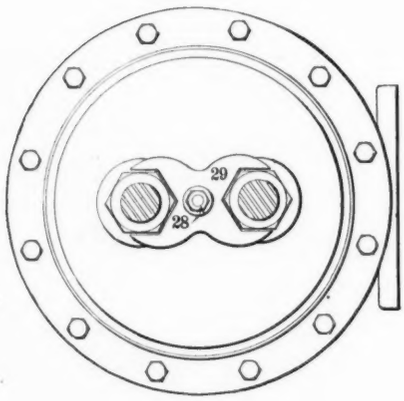


FIG. 75

In some cases the discharge tank may be so arranged as to cause an undue amount of air to get into the water, and if so it can be easily improved. If the discharge pipe is above the surface of the water in the tank, the stream falling into the tank will carry with it considerable air, and if the suction pipe is nearby, some of this air will be drawn into the pump. By placing a few division boards within the tank so as to space off the suction outlet, the water will have a chance to settle and free itself of most of the air before it is drawn into the pump.

To Remove Air from Lifting Cylinder

To remove air from the lifting cylinder, when the air has accumulated in sufficient quantity to cause the car to teeter noticeably when stopping, an air-cock is provided at the upper end. If this cock is left open while the elevator is running, all the air will be expelled after a few trips have been made. Most of the air, however, is forced out while the car is running down. On the up trip of the car, water rushes into the upper end of the cylinder from the circulating pipe and the surface of the water is kept well churned, so that water, as well as air, passes out through the air-cock; but on the down trip the piston moves upward, forces the water up against the air, and out into the circulating pipe. As the water surface remains comparatively quiet, air alone passes through the cock, and a far greater amount is expelled than in the other case. When all the air is out of the cylinder, the bouncing of the car will stop, and then the air-cock should be closed. The car would continue to run satisfactorily with the cock open, but there would be an unnecessary waste of water and the car would settle after stopping at a floor; hence, it is important to make sure that the cock is closed.

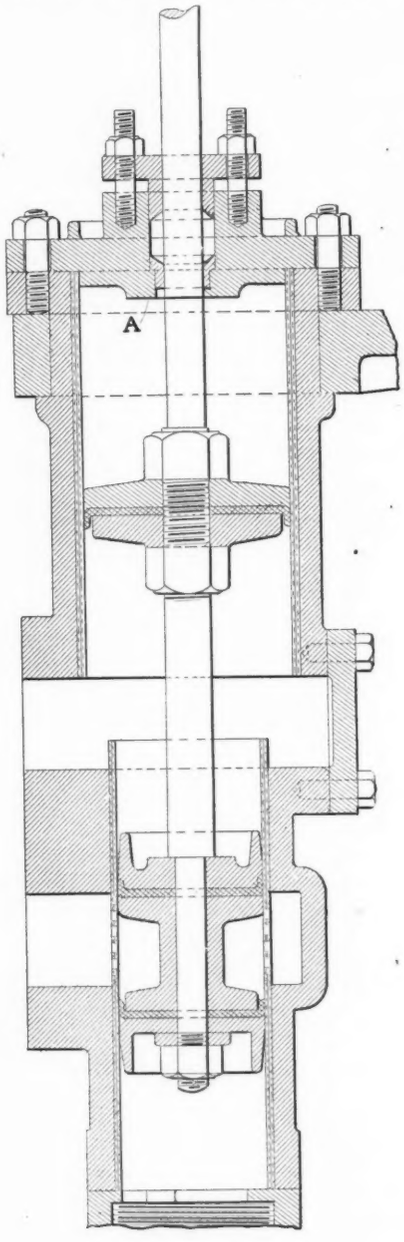


FIG. 76

Settling of the Car

Whenever the elevator car settles after stopping at a landing it is because there is a leak in either the piston or the valves. To determine where the leak is located, stop with the car above the lower floor, close the gate valve in the supply pipe, and move the main valve into position for the upward trip. If the car still settles, the chances are that the leak is in the piston, because the packings of the main valve will be above the port connecting with the lower end of the cylinder, and to circulate through the valve the water would have to pass by both packings. It is improbable that both packings would leak at the same time. While this is not a posi-

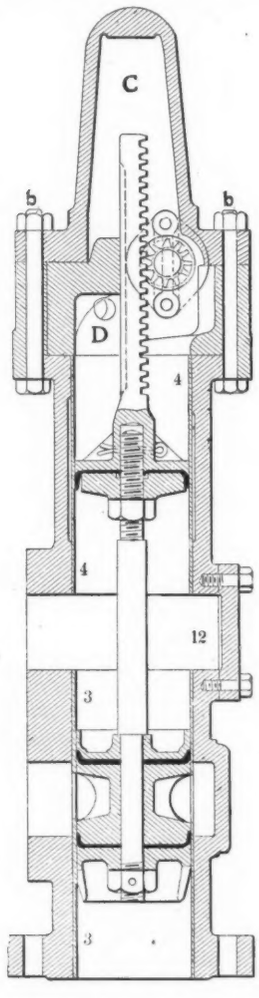


FIG. 77

tive test, it is the best available, and four times in five will prove reliable.

If it becomes necessary to tighten the piston packing, the way to do it will depend upon the type of packing and piston. Some pistons are designed to use a combination packing, consisting of a deep leather cup with an outside wearing surface of square-section rubber rings. The water presses the leather cup against the rubber, making a water-tight joint, at the same time forcing the rubber rings against the cylinder surface. The construction of this packing will be understood from Fig. 71. This style of packing was formerly used almost exclusively, and is to be found in nearly all the elevators which were installed fifteen or more years ago.

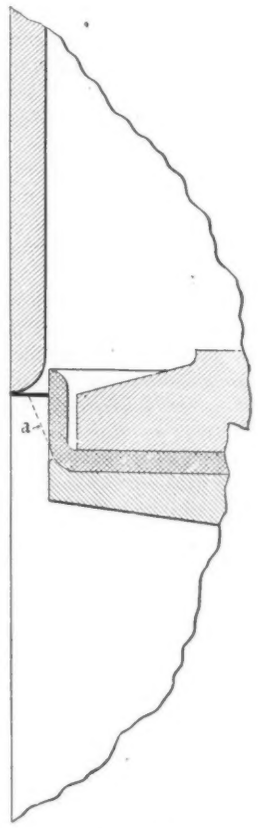


FIG. 78

In modern elevators the packing used for pistons is the same as that employed for steam-engine piston-rod stuffing-boxes, and the piston is made with a packing space, and a compressing ring to press the packing into it. The construction can be readily understood from Fig. 72, which shows one of the latest designs of pistons for Otis low-pressure, vertical elevators, although in this design the piston is packed from the upper side, while in the design most generally used it is packed from the under side. These pistons being provided with regulation stuffing-boxes, ordinary hemp packing can be used, but unless the packing is done with good judgment the results may be serious. This is true with regard to almost any kind of packing, but particularly with those that are apt to swell appreciably when they become wet. If the stuffing-box is packed very tightly with a dry packing, when it begins to absorb water it will begin to swell, and may continue to swell until it bursts the cylinder.

The bursting of hydraulic-elevator cylinders is not an unusual thing, and in the great majority of cases it is due wholly to excessively tight packing; there are elevator engineers who insist that this is always the cause. Even if the packing is not tight enough to burst the cylinder, it may be tight enough to absorb so much of the power of the water as to cause the car to run much too slowly, not to speak of the waste of power.

Packing the Piston

If the piston is made so as to be packed from the upper end of the cylinder, the course of procedure in packing is as follows: The car is run to the bottom of the elevator well; then the valve in the supply pipe is closed, to prevent water from flowing in from the pressure tank while the packing is being done. The next step is to remove the water in the cylinder above the piston, and this is accomplished by opening the air-cock in the upper cylinder-head, and also a valve that connects the drain pipe with a point on the side of the cylinder below the bottom of the piston, when the water will be drawn off into the drain pipe. After this much is accomplished, the cylinder-head is to be removed, but before doing this the position of the part which contains the piston-rod stuffing-boxes and the location of the outer clamping ring must be carefully marked, so that when the head is replaced the parts may be returned to their original positions.

It must be borne in mind that in removing the old and putting in the new packing, it is possible to impart to it a rotary movement that would throw the piston-rods out of line. When the cylinder-head has been removed, the stuffing-box gland-screws are removed, and the gland is raised out of the way; then the old stuffing is taken out and new put in, as in any other stuffing-box. It is to be observed, however, that as it is a far more laborious job to pack an hydraulic piston than a steam-engine or pump stuffing-box, greater care should be taken to make sure of not having to open up the cylinder a second time.

As before stated, not only is there danger of bursting the cylinder if the packing is pressed in too tightly, but even if this damage does not result, there will be excessive friction; therefore, every care must be taken not to get the packing too tight. At the same time it is necessary that it be tight enough to prevent the water from passing, and while it is not possible to give specific directions or signs by which to determine when the packing is tight enough, men of experience will have no difficulty in determining this point.

To avoid trouble in replacing the packing gland, it is advisable to mark the position in which it goes before removing it, so as to replace it in the same position. As it is necessary that the gland be screwed down evenly all around, that is, so that its outer surface may be parallel with the cylinder, the distance from its upper surface to the top of the cylinder should be accurately measured at four points equidistant from each other.

If, when the cylinder-head is removed, it be found that the piston is too far down to be reached conveniently, it can be raised by placing a clamp on the lifting ropes some distance above the car and drawing it down by means of a tackle attached to the upper frame of the car. In doing this care must be taken that the clamp is attached only to the lifting ropes, and not to those that run to the independent counterbalance. In cases where the machine is geared high—four or six to one—and the independent counterbalance is light, this method may not prove satisfactory, unless the car is loaded so that it cannot be lifted by this effort to raise the piston. The piston can also be raised directly by pulling up the traveling-sheave frame; but if this is done it will be necessary to be careful to return the ropes to their proper position when the frame is lowered, and in some cases this is not easily done on account of the sheaves not being in a position where the ropes can be readily reached. If the piston is raised so high as to bring the packing opposite the porthole connecting with the circulating pipe, care must be taken that in lowering it the packing is not caught, also that the packing is not forced out into the port while placing it in the stuffing-box.

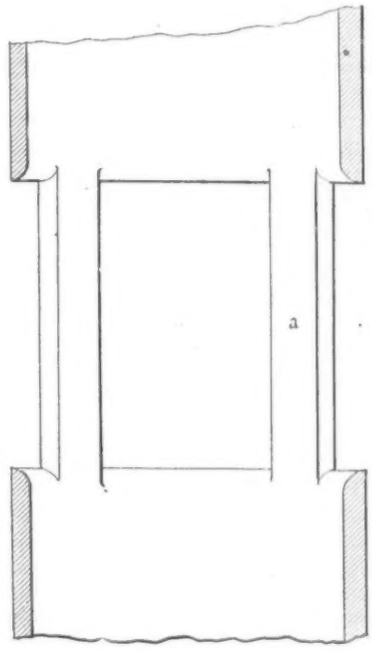


FIG. 79

After the piston is packed and the cylinder-head is replaced, one should see that the air-cock is open, and that the main valve is in the stop position. Then slowly open the valve in the supply pipe, and keep the air-cock open until water runs out of it, indicating that all the air is expelled; then close the air-cock and the elevator will be ready to run.

If the piston packing is of the leather-cup and rubber-ring type, the packing process is the same as described, with the exception that after removing the follower *F*, Fig. 71, the next step is to remove the leather cup and clean out thoroughly the packing space, and also the holes in the follower through which the water passes to press out the leather cup. If the cup is found to be in good condition, which is probable, it may be used again, but if much worn it must be replaced, and to get the new one in position it will be necessary to cut it carefully on a diagonal line, so as to pass it over the piston-rods; then it must be sewn up neatly (which is not an easy job), so that it may be of the same shape and size as before cutting. The rubber rings are to be replaced by others of the same size; the cross-section is generally ⅝ inch square. They should be cut somewhat longer than the circumference of the circle, say from ¼ to ½ inch, according to the diameter of the cylinder, so that the ends may be pressed tightly against each other. Three rings are usually required, and they should be of such thickness as not to fill up the space tightly, for if they do they may not be forced out against the cylinder wall by the leather cup. If they fit loosely, as shown in Fig. 71, they will be pressed out so as to make a tight fit.

If the piston must be packed from the bottom, the packing operation is the same as that just described, but the piston must be run down to the lower end of the cylinder, which means that the car must be run to the top of the building. In order that the piston may be brought low enough to be easily reached, it must be run down until it strikes the lower cylinder-head, and to do this in the case of a hand-rope-operated elevator it is necessary to slide up the stop-ball on the hand rope. In the case of a pilot-valve machine, the stop-ball on the rope that actuates the automatic stop-valve must be moved. In either case, the car is first run up as far as it will go, then the stop-ball is shifted to a point where it will prevent the car from moving far enough to get up a speed that would cause the piston to strike the cylinder-head hard, even if it were not run up carefully. In running up the car, however, the valve should be opened just enough to cause the car to move.

When the car is run up until the piston rests on the lower cylinder-head, it must be secured to the overhead beams by means of ropes several times as strong as may be considered necessary to hold it safely, say ten times as strong. This being done, the valve in the supply pipe is closed, and the car lever is turned for the down trip, so as to connect the circulating pipe with the lower end of the cylinder. The next step is to open the valves connecting the drain pipe with the side and bottom of the cylinder, and also the air-cock at the top, so as to drain out the water. If the discharge tank is higher than the bottom of the cylinder, the valve in it must be closed, so that the tank water may not run into the cylinder, as it would otherwise surely do, owing to the fact that the cup packings in the valve are not set so as to be tight against water running in from the discharge end of the valve cylinder. Having drained the cylinder the lower head is removed and the packing is done in the same manner as for top-packed pistons.

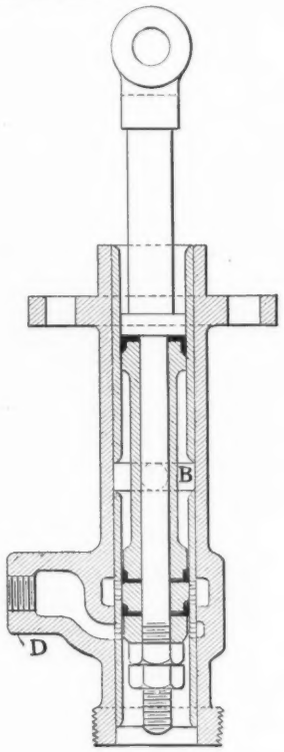


FIG. 80

In the latest designs of bottom-packed pistons, one of which is shown in Fig. 73, the packing chamber is made deep and the clamping ring *R* is screwed tightly against the bottom of the piston. This renders it unnecessary to measure the distance from the ring to the lower end of the cylinder to make sure that it is in its true position, because when screwed up tightly it will be true; but as there is no provision for adjusting the depth of the packing, the latter must be gaged in quantity so that it will be just tight enough when the clamping ring is screwed up. Owing to the greater amount of packing there is no difficulty in doing this, generally, without splitting any of the packing. When the piston is repacked, and the cylinder-head in place, move the main valve to the up-trip position, so as to just open, then open slightly the valve in the supply pipe, having first closed the valves connecting with the drain pipe. Leave the air-cock open and the cylinder will fill slowly with water, and the air will be expelled. When all the air is out close the air-cock, and return the main valve to the stop position; then open the supply-pipe valve wide, release the car and run it down a short distance; then reset the stop-ball, and the elevator will be ready to run.

The piston-rods pass through stuffing-boxes of the same type as those used on steam engines, as can be seen from Fig. 74, and they are packed in the same way. To keep the glands from working loose the locking piece *29* is provided, and this is secured in place by the stud *28*. The way in which the locking piece holds the stuffing-box caps is clearly shown in the plan view, Fig. 75. In repacking the piston-rod boxes, one should always be sure to replace the lock-clamp *29*, especially if the cylinder is located in the elevator well at one side of the car, because if the cap of one of the boxes should work loose, it might permit the water to spray out in sufficient quantity to give the passengers in the car an undesirable shower bath. Before starting to pack the piston-rods, the car should be run to the bottom of the building and the valve in the supply pipe closed, so as to remove the pressure in the cylinder, and thus prevent water from spurting out of the stuffing-box. It is also advisable to open the air-cock so as to be sure of relieving the pressure entirely. Flax packing is recommended for this service, and it should be about ¼ inch in diameter. About eight turns will be sufficient.

To Pack the Valves

To pack the valves they must be removed from the valve chamber, so they may be taken apart to remove the old cups and put new ones in their places. There is no difficulty in removing the valves from machines provided with a pilot-valve gear without a throttling valve, as there is nothing to interfere with the free withdrawal of the leather cups. This may be seen at once from Fig. 76, which is a vertical section of such a valve. It will be evident that both the small lower chamber and the large upper one are smooth, so that as soon as the valve-chamber head is removed and the connecting-rod is free, the valve can be drawn upward. In Fig. 77, which is a vertical section of a simple valve of the type used with hand-rope control, the cups of the lower valve have to pass over the space *12*, and thus are liable to catch on the upper lining *4*. This difficulty seldom occurs, however, because the inner edge of the lining is rounded off, in the manner illustrated in Fig. 78, so that the cup can spread out considerably before it will be caught, as indicated by the dotted line *a*.

These valves are not all made in this way. In many of them the linings *3* and

4 are combined in one, with ports cut through where the space 12 comes, the construction being as illustrated in Fig 79. If the valve chamber is constructed as in Fig. 77, and the cup appears to catch, it can usually be freed by gently rotating the valve, at the same time pulling it up just hard enough to make it lift if the cup slides back into position. If this method fails to free the cup, then the proper thing to do is to drop the valve back far enough for the cup to enter the line 3, and allow the valve to remain in this position for a few minutes, so as to allow the leather to set, and then try to lift the valve again, but with greater care.

Differential valves provided with a throttle generally work in chambers constructed as shown in Fig. 79, and with these, as well as with the rack and pinion valves of Fig. 77, that run in similarly-constructed chambers, there is no difficulty in removing the valve, because if the packings spread out and catch, they can be pressed back by simply rotating the valve, as the longitudinal connecting bars *a* will flatten down the raised edge of the cup.

To pack the main valve it is necessary to run the car to the top of the building and secure it there, the same as for packing the piston from the lower end of the cylinder, the only difference being that it is not necessary to lift the car any farther than it ordinarily runs. After firmly securing the car, the valve in the supply pipe is closed, and then the water is drawn off the circulating pipe by opening the valve that connects its lower end with the drain pipe. If the discharge tank is higher than the bottom of the valve this must also be shut off, so that the water may not run out of the tank through the valve chamber when the valve is removed.

If the valve is of the rack and pinion type used with hand-rope control, and illustrated in Fig. 77, all that is necessary after securing the car and closing the supply and discharge valves is to remove the bolts *b b*, and take off the cap *C* and the intermediate block *D*, which contains the bearing in which the hand-rope sheave rotates. This having been done, the valve can be removed. If the valve is of the differential type, as shown in Fig. 76, then the upper end of the valve-rod must be disconnected from the cross lever that connects it with the pilot valve, and the pipe connection with the upper head *A* must be broken; then the head can be lifted off and the valve drawn out.

The valves should be packed at a time when it is not necessary to hurry in getting the elevator back into operation, in order that the valves may be allowed to soak for an hour or two after the new cups have been put in place. To make sure that the cups are tightly clamped between the valve body and the head, it is advisable to drop a little oil on the flat part of the leather before putting it in place, so as to soften it. After the repacked valve has been replaced and the valve chamber properly closed, all connections having been correctly made, the valves in the supply and discharge pipes must be opened, also the air-cock in the top of the cylinder, so as to fill up the circulating pipe and dispel the air from the upper end of the cylinder; then close the air-cock and the elevator is ready to run.

To replace the cup packings in the pilot valve it is necessary to close the valve in the supply pipe, after running the car to the bottom of the well. If the discharge tank is higher than the valve, the discharge connection must also be closed. The valve, as may be understood from Fig. 80, can be drawn out of the chamber as soon as its upper end is disconnected from the connecting-rod. The cups at the lower end of the valve will have to pass up over the break in the lining at *B*, but as the inner corners are rounded off, there should be no difficulty in passing this point. Before removing the pilot valve it is advisable to draw just enough water from the circulating pipe to remove the pressure, in order that none may spill out through the top of the pilot-valve chamber. If the large valve at the upper end of the main valve, which is called the motor piston, is not tight, the pilot valve cannot be removed until all the water that is above the level of the pilot-valve chamber is drawn from the circulating pipe; otherwise, this water would pass by the motor piston into the upper end of the main valve chamber, and thence through the pipe connection to the inlet *D* of the pilot valve.

Gland Troubles with a Steam Turbine

By Edward Russell

The old type of steam-sealed gland is used in the majority of turbines, running or under construction, in England, whereas in America the water-seal type is being adopted in all cases. The only complaint I have heard against the latter gland came from Kimberley, South Africa, where the water is so bad that it used to fill the water space in the gland with solid deposit, but this has been since overcome by using condensed water.

The water gland appears to be by far the more economical. For instance, with a machine running on a traction load, the exhaust from the relay valve cannot be used for the simple reason that this varies exactly with the load, giving the largest exhaust when the load is the lightest. This would be a very serious drawback in a traction station, because at the heaviest load the glands would receive very little steam, with resultant loss of two or three inches of vacuum. This is overcome in traction work by sealing the glands with live steam, which is very wasteful practice on account of the relay exhaust being entirely lost. In a large turbine this exhaust will amount to a number of pounds in an hour. Of course, in throttle governing, such as used by Willans & Robinson, this is eliminated.

In lighting stations where the load is practically steady the relay exhaust works very well, but even here it has to be assisted with a little live steam. Vacuum has been seen to vary between three and four inches with steam from the relay valve alone; then when the load has practically dropped to zero, the steam has blown out from each gland in sufficient quantity to fill the engine room.

Then, too, I have noticed another thing. The old-style ring packings answer splendidly for machines running non-condensing, but are useless for running condensing, as the packing immediately burns up, causing no end of trouble to get the grooves clean again.

A large company in the north of England, which manufactures turbines, tried a water gland of the paddle-wheel type. It practically consisted of two grooved collars shrunk on to the shaft with a paddle-wheel between them. This idea was not given a fair chance, however, the result being that the whole thing was put in the lathe, the wheel turned off to a level with the two collars, then it was grooved and turned into a steam-packed gland. When these glands were put into service the fun began. The first one went on the machine that changed from non-condensing to condensing. The temperature being kept up by the sealing steam, the collars did not follow the contraction of the spindle; consequently, they shifted on the shaft and started to rub. This added more heat, which helped to increase the expansion, resulting in showers of brass from the strips which were calked into the gland, at the same time setting up heavy vibration.

Another one went in on starting up. The machine had been well warmed up and the glands sealed to pull a vacuum, with the result that when the machine had been running a few minutes both glands fired. Anyone who has not had the misfortune to witness a gland properly fired has no idea what a brilliant display it makes. One thing is certain: If there is any loose part in the machine it will soon make itself evident!

These cases simply show one of the drawbacks to steam-sealed glands, especially when using live steam with a gland simply shrunk on.

On July 1 the New York Central & Hudson River Railroad took off its last steam trains running into its Forty-second street terminal, and substituted electric locomotives for them, thus completing the electrification of the system to High Bridge on the central division and Wakefield on the Harlem division.

Apparatus for Analyzing Flue Gases

An improved Orsat apparatus of his own design was described by A. Bement, American Trust building, Chicago, at a

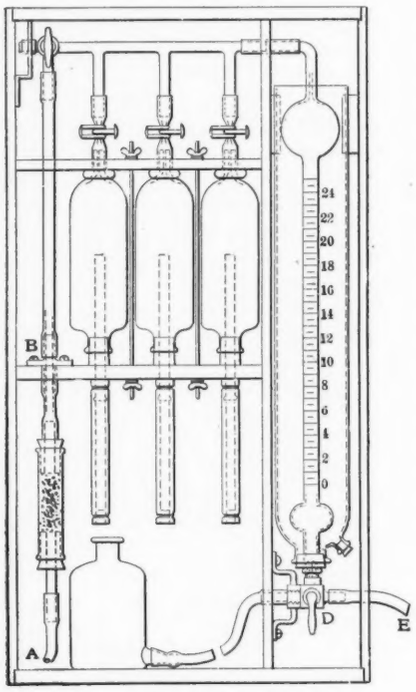


FIG. 1. BEMENT'S IMPROVED ORSAT APPARATUS

recent meeting of the American Chemical Society. The distinguishing features are that gas may be aspirated through the burette; also that absorption in the pipettes may be accomplished without displacement of the gas volume by means of the leveling bottle, as is necessary with the usual pipette, so that one introduction of the gas to the pipette suffices, agitation of the reagent being accomplished by means of a simple form of pump, which consists of an orifice formed by a glass tube, to the lower end of which is attached a rubber connection, compression of which causes the reagent to be projected into the confined gas, the pipette containing no glass tubes.

Referring to Fig. 1, gas enters by a rubber connection *A*, passing through a cotton filter shown, which is attached by tubing to a fitting *B*, which takes any strain brought upon the connection. From this point the gas flows up to a cock, which is provided with the regular three-way openings, and across the capillary connection it flows down through the burette, passes a three-way cock *D*, at the bottom, and out by way of the connection *E*. The flow of gas through the instrument may be produced by any usual means. In this way all of the old gas is expelled and an entirely new sample is secured within the burette, after which, by the manipulation of the two cocks, it is immediately confined, and by turning cock *D* to the left-hand horizontal position, the passageway to *E* is closed and a corresponding connection established between the burette and the aspirator bottle. Then manipulation is precisely the same as with the Orsat apparatus as far as leveling and manipulation of the gas by the aspirator bottle is concerned. When the cock *D* is in position for the flow of gas by way of the passage *E*, it, of course, is closed off in the direction of the aspirator bottle. When the sample of 100 cc. has been secured, the leveling bottle is raised and the pinch-cock at the neck of one of the pipettes is opened, the gas being forced therein, after which the pinch-cock is closed, confining the gas to the pipette, then by compression of the rubber projection below, the reagent is projected in jet form into the gas, which may be continued as long as necessary, after which the gas is withdrawn and measured. By this means it is often possible to secure complete absorption by one exposure in the pipette, and it is sometimes convenient when the attendant has other matters requiring his attention, to allow the gas to remain in the pipette while he gives mo-

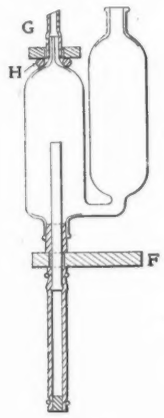


FIG. 2

mentary attention to other things; or the manipulation of the absorption process may continue, even if his attention is not directly upon it, which is something impossible with the usual form of pipette.

Fig. 2 is a cross-sectional elevation of the pipette and its associated features. *F* is a shelf upon which it rests, and *G* a binding-piece held down by means of rods and thumb-nuts, this binding-piece being kept in place by guides located at its ends and fastened to the sides of the instrument case. *H* is a rubber washer located between the top of the pipette and the binding-piece. As will be observed, the bottom end of the pipette is closed by a pierced rubber stopper, through which a glass tube projects. The lower end of this tube has fastened upon it a piece of 3/8-inch of 7/16-inch rubber tubing closed at the lower end by a plug as indicated. The positions of the glass tubes are such that there is always a suffieient seal of the reagent over their ends. Compression of the rubber extension causes a corresponding quantity of reagent to be discharged through the tube and into the gas, and when the rubber extension is released, a similar quantity of reagent returns to its interior.

The burette is surrounded by a water jacket as indicated, having at the bottom an opening provided with a stopper for drainage. The burette at its lower end has an enlargement; this is to insure that a considerable quantity of gas larger than 100 cc. is first obtained, a matter which is of considerable importance in those cases where gas may be drawn from a source at a pressure below that of the atmosphere. In the particular instruments which Mr. Bement has had made for combustion gases, the stem of the burette is of smaller diameter than usual, so that the entire contents are not greater than 28 or 30 per cent. of the burette. This makes possible finer divisions being graduated thereon, which read to 0.01 per cent.

The cock located at the lower end of the burette has in all cases been made of metal, and has proven more satisfactory than those of glass; those at the top of the pipette formerly employed, Mr. Bement was compelled to replace with pinch-cocks, owing to the difficulty of obtaining carefully made and durable glass cocks.

Charles J. Wilson described before the Institution of Civil Engineers the portable apparatus for the analysis of flue gases illustrated in Fig. 3. *L* is a eudiometer, in which the gases are measured, connected by a capillary tube with a "laboratory vessel" *C*, in which the absorptions take place. Between *L* and *C* is a glass

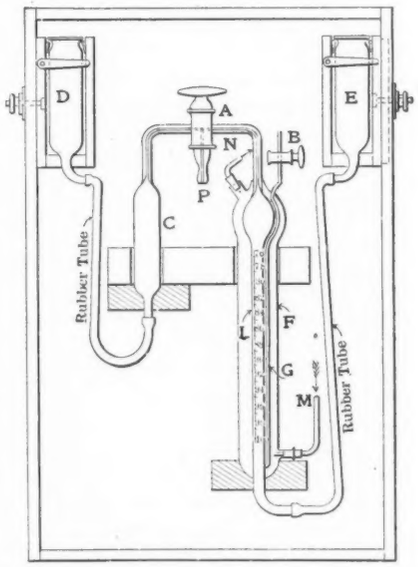


FIG. 3. WILSON'S PORTABLE GAS-ANALYSIS APPARATUS

stop-cock *A*, by means of which communication can be established either between *L* and *C*, or between either *C* or *L* and the point *P*. Both the eudiometer and the laboratory vessel are connected, by means of india-rubber tubing, with movable mercury reservoirs *D* and E, the ad-

justment of which in a higher or lower position gives the necessary pressure for the transfer of gas or liquid in either direction. In order to insure uniformity of temperature during the progress of an analysis, the eudiometer is water-jacketed, and as it would be difficult to adjust the vessel *E* so that the level of the mercury in it was precisely that of the mercury in the eudiometer, a comparison tube *G* is provided. The eudiometer is calibrated from the point where the capillary tube opens into it at the top to a mark at the bottom bearing the number 100. This space is 50 cubic centimeters, but it is divided into 100 parts for the convenience of reading off directly percentages by volume. The apparatus is filled with mercury, thus avoiding the errors which are liable to creep in when a gas apparatus is worked with water or a saline solution. The absorbents are drawn into the laboratory vessel, and the tube connecting them absorption has taken place, the gas is returned to the eudiometer for measurement, and the reagent is expelled at the point *P*. After a reagent has been used in the laboratory vessel, water can be introduced into it in order to wash it—and the mercury contained in it—quite clean before any mercury is sent from the laboratory vessel to the eudiometer, thus keeping the latter clean. Moreover, after an analysis has been made, the eudiometer, the laboratory vessel, and the tube connecting them, can be easily washed out with dilute acid before another gas sample is introduced.

It is of the utmost importance that the apparatus should be kept as clean as possible. The mercury, when dirty, should be cleaned by shaking it up with finely powdered cane-sugar and filtering it through a pin-hole in a cone of filter paper, or by some other method. The stop-cocks *A* and *B* require lubricating; only castor oil should be used for this purpose, and of that as little as possible. Should the inside of the apparatus become greasy, it can be cleaned by running methylated spirit through it.

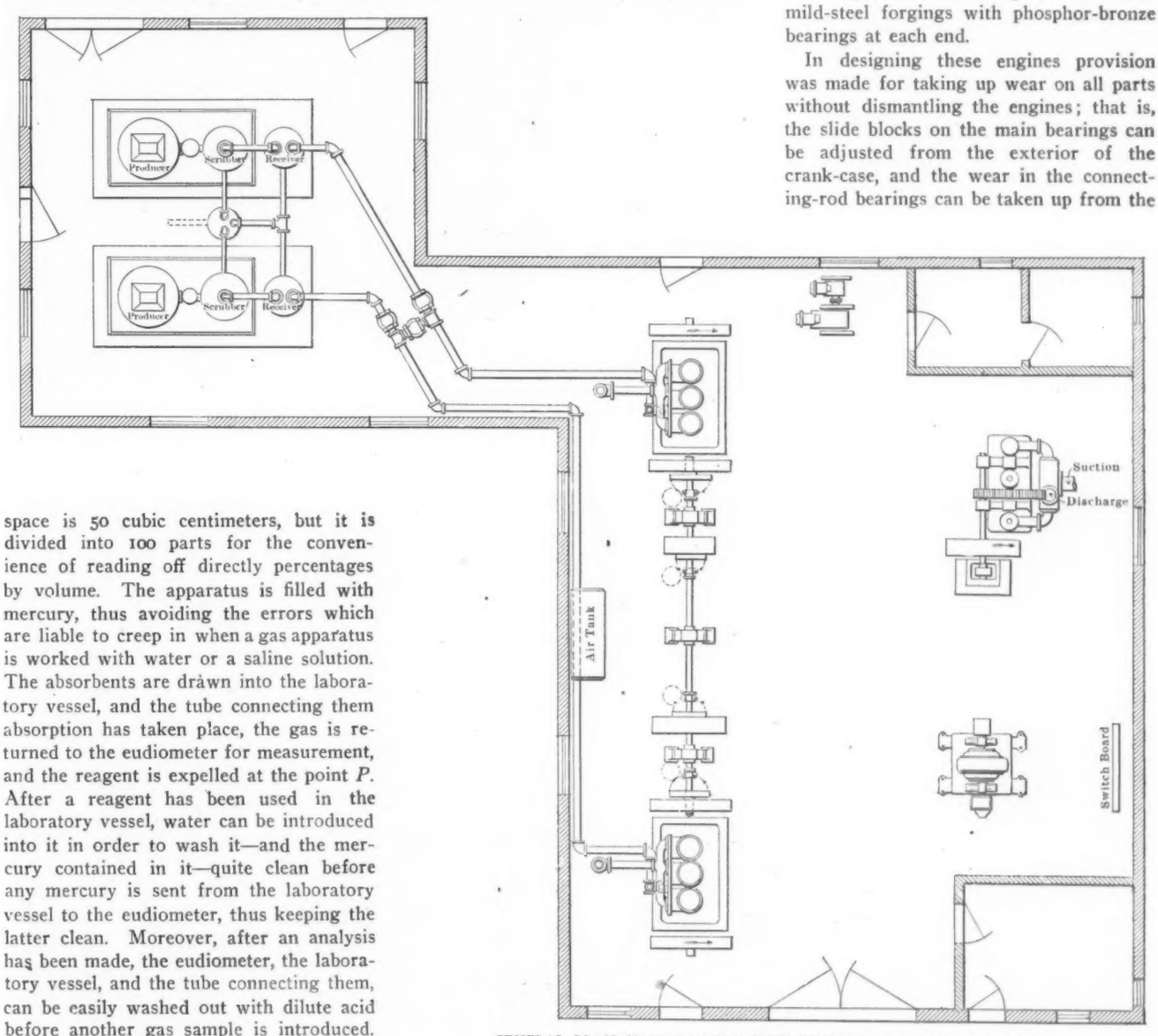
Suction Gas Producer Plant at Rocky Ford, Colo.

The city of Rocky Ford, Colo., recently installed two 100-horse-power Weber gas engines and suction gas producers for operating its water and light plant. Both engines are direct-connected by clutches to a 20-foot 5-inch shaft, from which are driven one 65-kilowatt 2200-volt alternator, with direct-connected exciter, and one 12x14-inch Deane triplex pump of a capacity of 1000 gallons per minute at 100 pounds pressure. There is also operated from the shaft, by friction drive, a 5-kilowatt generator used for lighting the plant. One engine and producer drive this machinery continuously, while the other engine and producer, installed for reserve purposes, are always ready for service in case of fire alarm or accident.

The engines are of the three-cylinder vertical type, especially designed for operating on producer gas. They are governed by a ball governor of the throttling type, driven by a secondary shaft, the governor actuating a special intake valve which directly controls the air and gas supply. The cylinders are 14 inches bore by 15 inches stroke, and the speed is 280 revolutions per minute. The pistons, wrist-boxes and crosshead bearings are oiled by the splash system, the crank-case being inclosed and filled with oil. The crank-shafts are cut from solid forgings made from mild-steel billets; the pistons are of the trunk pattern, fitted with patent cylinder rings; the connecting-rods are solid mild-steel forgings with phosphor-bronze bearings at each end.

In designing these engines provision was made for taking up wear on all parts without dismantling the engines; that is, the slide blocks on the main bearings can be adjusted from the exterior of the crank-case, and the wear in the connecting-rod bearings can be taken up from the outside of the engine by means of a special socket wrench applied directly through the cylinder and the piston, suitable openings being provided for that purpose.

A 5-horse-power gasolene engine, direct-connected to an air compressor, is used in starting the engines. This gasolene engine is also belt-connected to an exhauster, which is used to build up the fires in the producers while the compressor is getting up air pressure; so that as soon as the air pressure is sufficient to



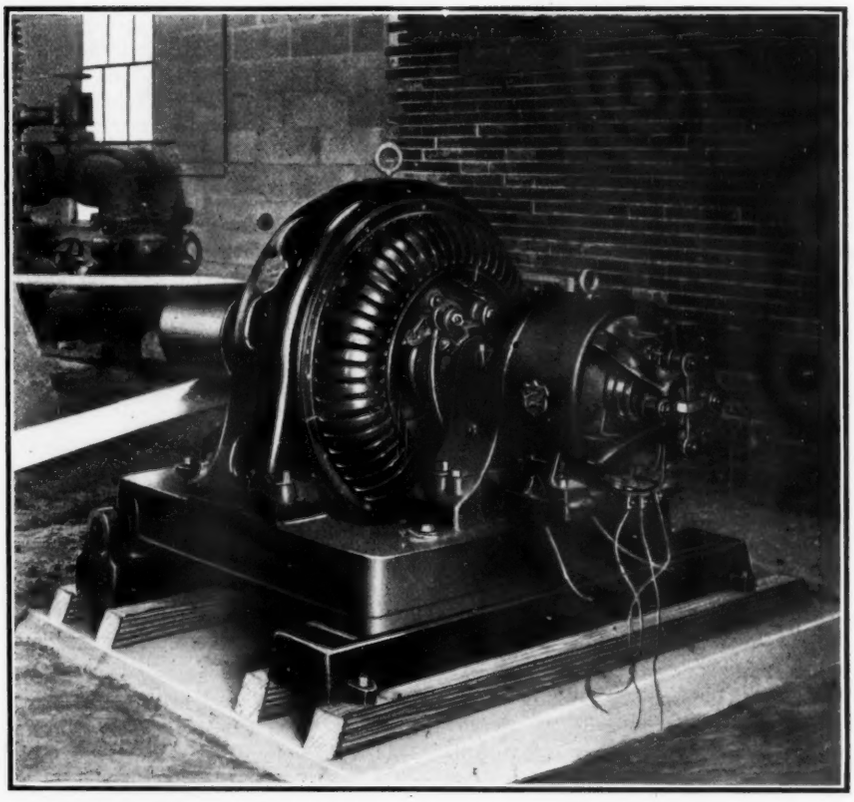
GENERAL PLAN OF THE ROCKY FORD SUCTION GAS-PRODUCER PLANT

start the engine, the gas producers may be in condition to furnish gas.

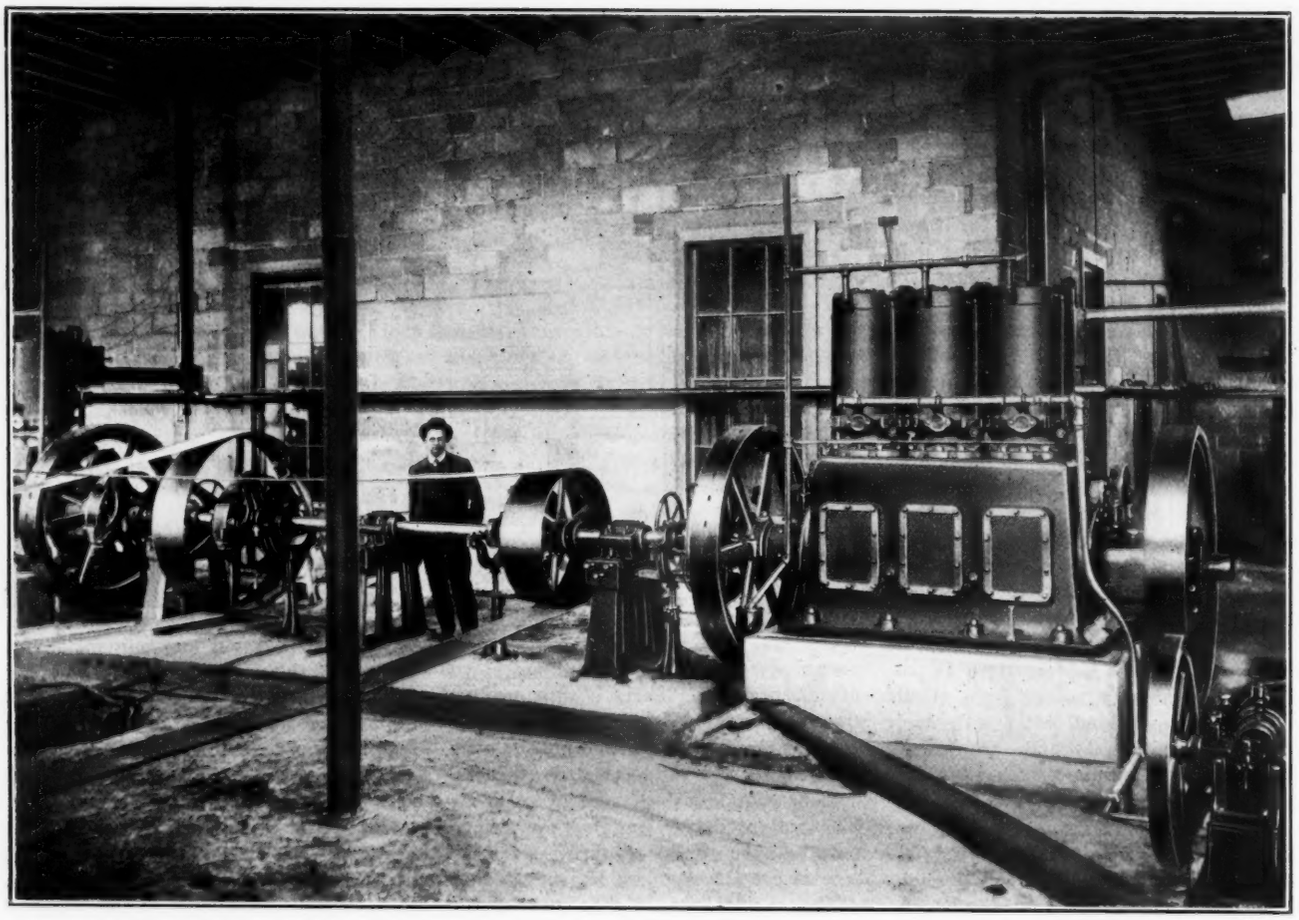
The ignition system is of the positive make-and-break or "hammer" type, the current for which is supplied from friction-driven magnetos.

The Gas Producers

The gas producers are located about 90 feet from the engines and are cross-connected, so that either engine can operate on either producer, or both at the same time. The producers are especially built for operation on Colorado anthracite, an inferior grade of coal costing $7 per ton. Each producer unit comprises a generator, vaporizer, scrubber and receiver. The generator consists of a cylindrical shell, lined with fire-brick and fitted with the necessary grate, a charging hopper and a blower; there is provided a separate vaporizer, through which the hot gases travel from the generator, for producing the necessary steam to supply hydrogen to the gas. An ordinary scrubber is used for cleansing and cooling purposes. The gas, after leaving the vaporizer, flows through a water bath at the bottom of the scrubber, then up through the scrubber proper, which is filled with coke covered by a continuous spray of water, and is then delivered to a gas receiver, or holder, from which it is taken by the engine. The



THE GENERATOR AND ITS EXCITER



100-HORSE-POWER TRIPLE-CYLINDER WEBER GAS ENGINE AND SHAFT CONNECTIONS

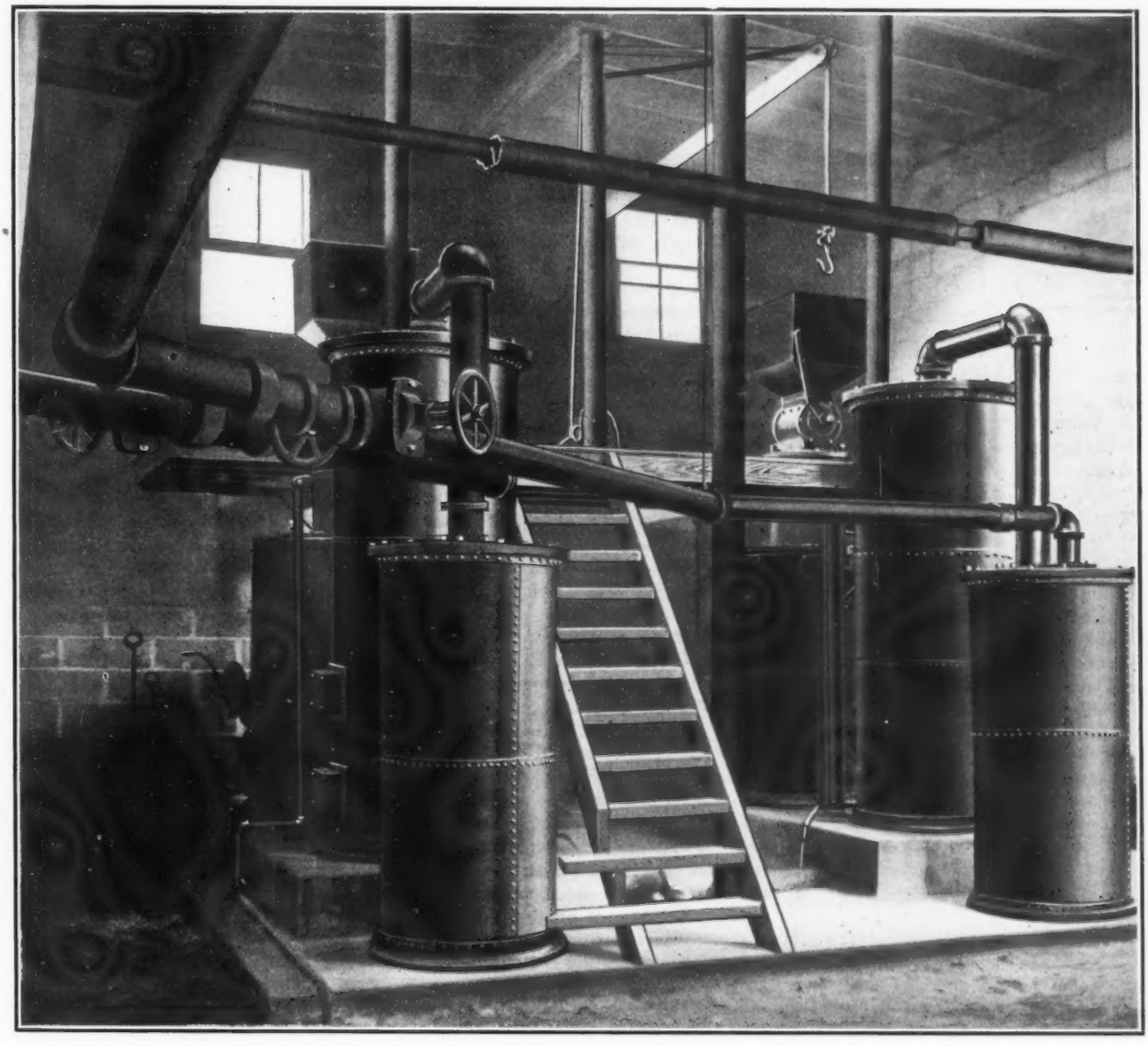
gas made from the Colorado anthracite contains 140 B.t.u. per cubic foot and is compressed in the engine cylinders to a pressure of 150 pounds per square inch.

A final test of the machinery was made after the plant was completed, to ascertain how quickly the plant could be made to respond in an emergency. One engine was put in operation, driving the generator and pump, and a fire alarm was turned in; the pressure was immediately raised from 40 to 100 pounds. Also, it took only five minutes from the time a signal was given to put the reserve engine into operation and shift the load to it, with a reported speed variation at the original engine of less than 2 per cent. during the entire change. It is further stated that the plant is operating upon one pound of coal per brake horse-power-hour.

There are 60,000,000 atoms in one cubic inch of copper, according to the calculation of an English scientist.

The Gas-engine Industry in Germany

The London *Engineer,* in a recent review of the engineering industry in Germany in 1906, raises the question whether the firms building large gas engines using blast-furnace gas found it profitable, at least during the first half of the year. Koerting Brothers, Hanover, who showed reduced profits in 1905, reported that "the gas-engine business, in consequence of severe competition from firms who had recently entered into this branch of manufacture, and also by the competition of the steam turbine, had become distinctly less profitable." Again, in the report for 1905-6 of the Gas Engine Works Company, Deutz, Cologne, the largest gas-engine works on the Continent, with branches at Milan and Vienna, having a total capital of £750,000, and which earned in 1905-6 net profits of £79,900, it was stated that in consequence of the severe competition among makers of large gas engines, the company had temporarily withdrawn from tendering for such engines and had confined itself to the production of smaller ones, with the result that while the total turnover fell by £16,000, the total number of gas engines produced increased by 243. As the result, however, of an understanding effected among the makers of large gas engines, later in the year, which had the effect of bringing about better prices, this firm recommenced the manufacture of them. It was added that the sale of the medium and smaller engines, both at home and abroad, had increased, but that whether in future this would be maintained was not clear, owing to the new tariffs, especially in Spain, which is a large consumer of German gas engines. With reference to the Russian market it was stated that, although the inquiry for gas engines was satisfactory, yet, in conse-



TWO 100-HORSE-POWER WEBER SUCTION GAS PRODUCERS AT ROCKY FORD, COLO.

quence of the inability to secure acceptable terms of payment, much of the business offered was lost. The Cologne Gas Engine Company sustained a loss of £5282 in 1905, while the Suction Gas Engine Company, of Hanover, increased its capital by £5000. The Rhenish Gas Engine Company, after passing its dividend for three years, earned in 1905-6 the satisfactory dividend of 7 per cent., and raised its capital by £50,000 to £200,000.

Different Styles of Connecting-rods Compared

By C. R. McGahey

The connecting-rods used on the engines of today make quite an interesting study.

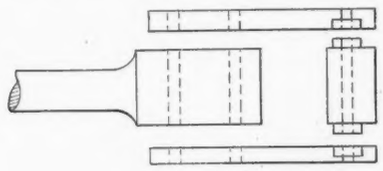


FIG. 1

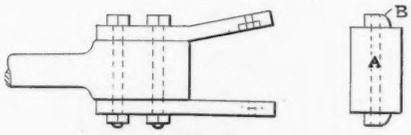


FIG. 2

It is a fact that more engine wrecks have been due to the connecting-rod than any other single cause. The rod catches all the vibration of the engine, and while this may not amount to much when the engine is new and the piston and valves are tight, affording proper steam cushioning, when the engine becomes worn the conditions change. The working joints have more play and induce more vibration throughout the whole engine. Bearing

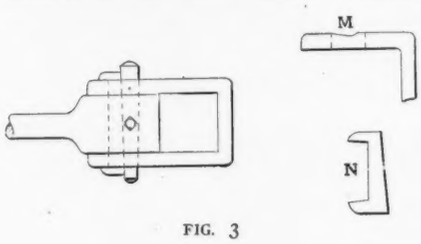


FIG. 3

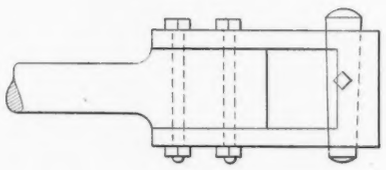


FIG. 4

this fact in mind, connecting-rods should be made in as few pieces as possible.

Fig. 1 illustrates a rod end that is unquestionably of the worst construction designed. It is made in six pieces, counting bolts. It may look well on paper, but Fig. 2 is a fair illustration of how this rods acts in practice, *A* showing the end piece. The doweled ends wear off as shown at *B*. This is a case of vibration

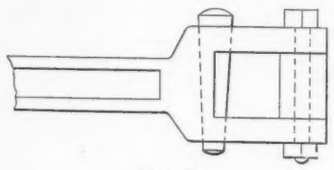


FIG. 5

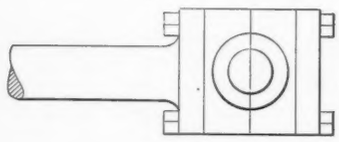


FIG. 6

first working the bolts loose, then the strap begins to work loose, and soon the engine will be wrecked. Sometimes a week only is sufficient to bring about this condition.

Fig. 3 shows the old-style rod and gib key so commonly used. This may have some faults, but it is far superior in practice to the one shown in Fig. 1. At *M* is shown how the head of the gib key usually works into the strap, when the whole thing begins to work loose and the key comes to look like *N*. This is especially

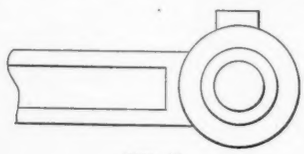


FIG. 7

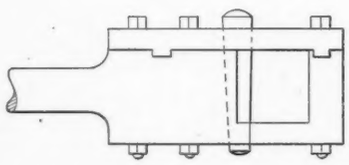


FIG. 8

so in high-speed work, where there is more vibration and consequently more wear, and the entire rod end soon becomes distorted. The brasses become loose in the seat, the vibration continues, out goes the key and away goes the engine.

Fig. 4 shows a much better construction of a rod end in which a key is used, and it has been known to give good service. The two bolts are drawn down solid and the end of the strap is solid, the key being mortised through the end for adjustment. This will wear somewhat better than that shown in Fig. 3.

Fig. 5 shows a rod end much used in locomotive practice and when properly built, by making the end bolt strong and pulling it up as tightly as most bolts are pulled in locomotive work, it stands well and few failures result. This construction is reduced to few parts and consequently is more safe in practice.

Fig. 6 shows what is usually known as a "marine" end. This is a fine wearing end, if made strong and firmly bolted up against the liners, but it requires a great deal of time to adjust. However, it wears well in good hands.

Some ugly wrecks have been caused by the rod bolts in this construction becoming loose from constant vibration, letting the end out and causing the engine to go to pieces, but it gives satisfaction if properly kept up.

Fig. 7 shows a solid end which has a brass ferrule pressed in it, and which is frequently used in locomotive practice. When worn the brass ferrule is usually pressed out, thin liners placed around it, and the ferrule is then put back. This

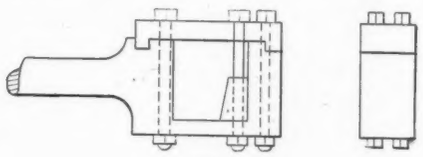


FIG. 9

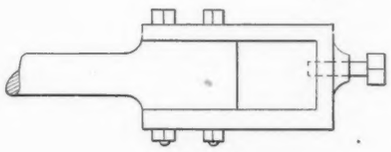


FIG. 10

compresses the ferrule and closes the hole.

Fig. 8 shows a good, solid rod, in which the rod has a solid end and the top part comes off. This makes quite a safe rod and is well suited for center-crank engine work. It makes a safer rod than that shown by Fig. 6 for this class of work.

Fig. 9 shows the same rod end made a little differently. This makes the best end for a center-crank engine where one is compelled to use an open-end rod. With the wedge adjustment it makes an excellent and very safe rod end.

Fig. 10 is an end used by some of the large engine manufacturers, but it has one serious objection and that is that all the thrust is carried on the point of the bolt.

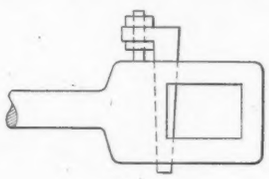


FIG. 11

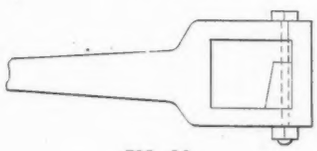


FIG. 12

But even with this drawback it makes a good strap-end for small engines, and by taking care in its use it is quite safe.

Fig. 11 shows a solid rod end that is much used in river steamer work and

makes a fine job. The key has a bolt to keep it from vibrating out and, the end being solid, the engineer can feel quite safe on the journey, as far as the rod is concerned.

Fig. 12 shows a similar end much used on high-class stationary-engine work, and I see no reason why it should not be used on all side-crank engines. It is a safe end and inexpensive. This rod should always be made as shown in Fig. 13, for by placing the wedges this way the rod centers are always kept about right. In the other case, as shown in Fig. 14, the lengths of the rod centers are always changing and this form should not be used, as it causes the striking points to change and endangers the running of the engine.

On the whole the solid rod has fewer wrecks charged to it than any other known form, and it ought to be more generally used in engine construction.

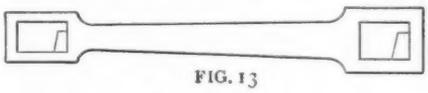


FIG. 13

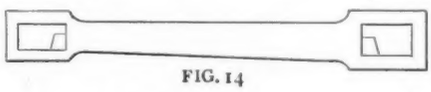


FIG. 14

A Wire-wound Wood-rim Fly-wheel

By E. E. Clock

There is a growing demand for wood-rim fly-wheels, and to meet this demand several manufacturers make a specialty of this type; but the only wood-rim wheel which heretofore has had a legitimate claim to greater strength than a well-constructed sectional cast-iron wheel, such as is usually supplied by reliable engine builders, is one in which the rim is laminated continuously, with the joints lapped and staggered so that at least 75 per cent. of solid timber may be counted upon for strength; that is, that not more than 25 per cent. of the joints shall be in line across the centers of the rim sections. The wheel referred to has always been considered the strongest made, so far as withstanding centrifugal force is concerned, but it is expensive. Engine builders have "shied" at it, and have supplied it only when the buyer insisted upon it.

In building one of these wheels, the largest part of the work must be done at the plant where the wheel is to be erected, with the consequent heavy expense of working men away from the shop, the undesirable feature of work and workmen being free from the rigid supervision of the shop management, and limited facilities.

An engine builder, in justice to himself and his customers, would naturally prefer to reduce the cost of an engine and improve the design and workmanship, and these are best conserved by having the maximum amount of work done at the shop. Therefore, attention is directed to the wire-wound wood-rim wheel which is the subject of this article. This wheel is built in eight, ten or twelve sections, according to the diameter of the wheel, and with one or two sets of arms, depending upon the width of face. The sections come together at the arms. They may be made of a white pine known to the trade as "No. 1 common," care being taken that defects do not occur near the face, and that the timber does not contain dry-rot. This being a cheap grade will reduce the cost of timber alone about 40 per cent. The sections are made up in the shop and shipped ready to be assembled.

A good way to build the sections is to provide a skeleton form to inclose each on the convex or belt side, and on the ends, as well as the part contiguous to the arm, these forms to be upright straight edges, it being understood that the section is constructed on its side. After the entire wooden part of the section has been put together, the narrow piece which covers the wire trough on the belt side, having been laid in without nailing, may be removed, so the lining for the wire troughs may be put in place temporarily for transportation. This lining consists of iron plates, ⅛ inch thick, the bottom plate being the full width of the trough, with the side plates resting on it. The cover plate is then placed in position, held by cross-bolts, and the section is ready to ship.

In building up the section it is preferable to use a good, stiff compound or varnish, rather than glue, on account of the moisture necessarily introduced into the wood with glue, and also because glue has a tendency to rot. The permanency and preservative qualities of boiled linseed oil with rosin, applied hot, can be warmly attested.

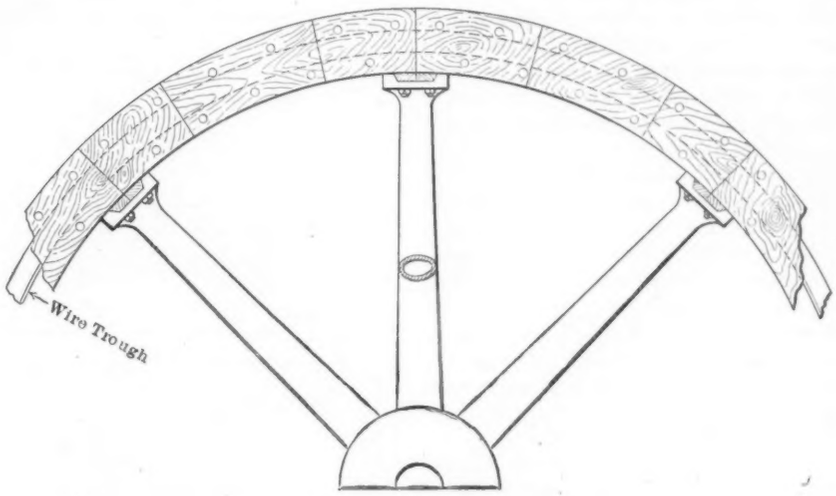


FIG. 1. SEGMENT OF WIRE-WOUND WHEEL

Having arrived at the place of erection, after the arms are set up the sections are located, and when all are in place the wiring is done. First, the narrow strips which cover the wire troughs are removed and the iron lining taken out and shifted so that the ends of the iron plates join in the middle of each wood section; the bottom plates are secured with numerous screws of ample length, the side plates being fastened with shorter screws.

Near the face of the wheel are erected a pair of stout stanchions for each wire trough, and between them is placed a thread mandrel around which the wire is given turns enough to heat the wire slightly, and to provide the necessary tension, so that the wire is literally stretched on to the rim. An end of wire

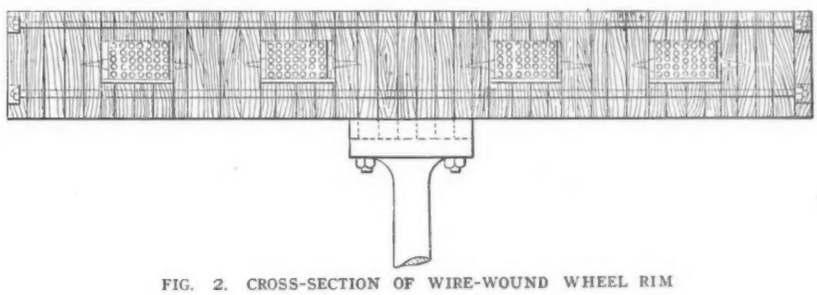


FIG. 2. CROSS-SECTION OF WIRE-WOUND WHEEL RIM

is fastened in each wire trough by drilling a hole in one corner of the bottom plate and, first smoothing the sharp edges of the hole, a turn is made around a screw and the screw sunk in the wood through the hole in the plate.

When the wire has been secured in each trough and properly wound around the mandrels (which may be ordinary jack-screws), and the reels of wire have been mounted on spindles so they will be free to pay out, there should be arranged on the opposite side of the wheel in each wire trough a spring wiper or drag that will ride hard on the wire in the trough, so that in the event of a wire breaking the whole will not get away. The wheel should be turned slowly by means of a small auxiliary engine so it can be stopped in less than half a turn. The wire should be guided so that on the first turn it will lay closely in the corner and each succeeding turn should lay close to its predecessor, so that the layer of wire will just fill the trough, with no spaces between wires. A good quality of No. 6 steel wire, slightly tinned, should be used.

At the completion of each layer the wires should be soldered about every 15 feet, by means of a blow-torch, using rosin as a flux, but without acid. The solder should be even, not lumpy, as the whole wire structure in each trough should be a sort of composite steel band, with each wire bearing its proportion of the strain.

After the wiring is finished the coverings are put on with cement and nails; then the upper cross-bolts are inserted, those under the trough bottom having been placed when the wire was being wound. Lastly, the wheel is faced on the sides with wood sections of better material and free from knots. These are made as long as possible, the longest being bridged across the joints, and all being secured with long screws. This outside facing is provided with holes over the cross-bolts, so that the nuts can be tightened as required.

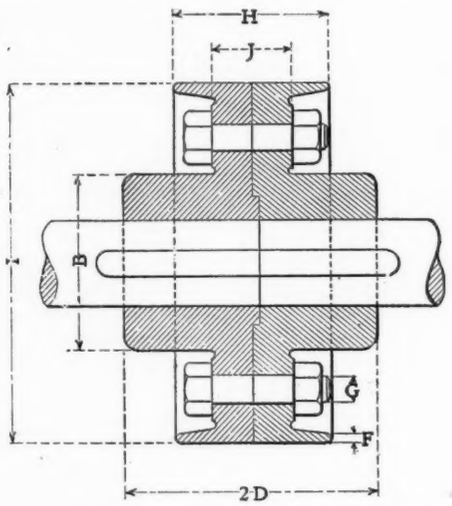
A wheel such as that described above can be constructed with a bursting-speed limit of six miles per minute.

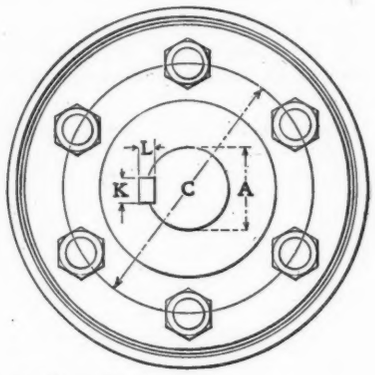
The McCall Ferry Power Development

An excellent account of the power development at McCall Ferry, on the Susquehanna river, elaborately illustrated by outline and half-tone engravings, is being issued for gratuitous distribution by the McCall Ferry Power Company, 60 Wall street, New York. The river is being spanned by a concrete dam sectionalized at intervals of 40 feet for the introduction of compressible material to avoid contraction and expansion strains. Ten vertical wheels rating 13,500 horse-power each will be installed.

Approved Proportions of Flange Couplings, Clutches and Wrenches

For the accompanying tables of approved proportions of flange couplings, clutches and wrenches we are indebted to John D. Adams, of the United States Surveyor-General's office, at Phœnix, Arizona. They were compiled from information collected in the course of Mr. Adams' practice and have been proved by extensive use.





E = No. of Bolts

A	B	C	D	E	F	G	H	I	J	K	L
1 5/16	2 3/8	5 1/8	2 1/8	4	5/32	1/4	2 3/8	7 1/8	1 5/16	3/8	1/4
1 7/16	2 3/8	5 11/16	2 3/8	4	3/16	1/4	2 3/4	7 7/8	1 3/8	3/8	1/4
1 9/16	2 3/8	6	2 15/16	4	3/16	5/8	2 3/8	8 1/4	1 7/16	3/8	1/4
1 11/16	3 1/8	6 5/16	2 15/16	4	1/4	5/8	3	8 3/4	1 1/8	1/2	3/8
1 13/16	3 1/8	6 7/8	3 1/16	4	1/4	11/16	3 1/8	9 1/4	1 9/16	1/2	3/8
1 15/16	3 1/8	6 15/16	3 1/4	4	1/4	11/16	3 1/4	9 3/4	1 5/8	1/2	3/8
2 1/16	3 1/8	7 1/4	3 1/8	4	1/4	3/4	3 1/8	10 1/8	1 11/16	1/2	3/8
2 3/16	4 1/8	7 5/16	3 1/2	4	5/32	3/4	3 1/2	10 1/2	1 3/4	9/16	3/8
2 5/16	4 1/8	7 3/8	3 3/8	5	5/32	3/4	3 3/8	11	1 13/16	9/16	3/8
2 7/16	4 1/8	8 3/16	3 3/4	5	5/32	3/4	3 3/4	11 1/2	1 7/8	9/16	3/8
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2 11/16	5 1/8	8 7/8	4 1/16	5	5/16	3/8	4	12 1/2	2	5/8	7/16
2 13/16	5 1/8	9 7/16	4 3/8	5	5/16	1	4 1/4	13 1/4	2 1/8	3/4	1/2
3 3/16	6 1/8	10 1/8	4 5/8	5	3/8	1	4 1/2	14	2 1/4	3/4	1/2
3 5/16	6 1/8	10 7/16	4 3/4	5	3/8	1 1/8	4 5/8	14 1/2	2 5/16	3/8	9/16
3 7/16	6 5/8	10 3/4	4 15/16	5	7/16	1 1/8	4 3/4	15	2 3/8	3/8	9/16
3 11/16	7 3/16	11 3/8	5 3/16	5	7/16	1 1/8	5	15 1/2	2 1/2	1	5/8
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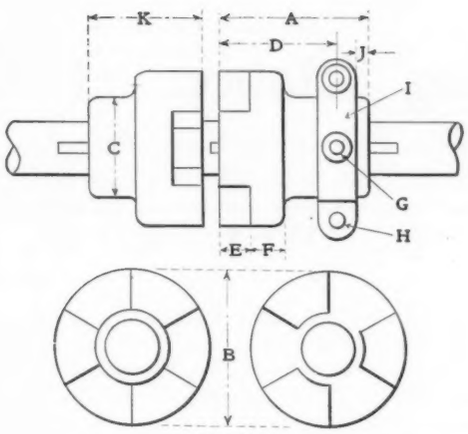
3 15/16	7 11/16	11 3/4	5 1/2	6	1/2	1 1/4	5 1/4	16 3/4	2 5/8	1	5/8
4 3/16	8 3/16	12 3/8	5 3/4	6	1/2	1 1/4	5 1/2	17 3/8	2 3/4	1	5/8
4 5/16	8 7/16	12 7/8	5 15/16	6	9/16	1 3/8	5 5/8	18 1/4	2 13/16	1 1/8	11/16
4 7/16	8 11/16	13 1/4	6 1/16	6	9/16	1 3/8	5 3/4	18 7/8	2 7/8	1 1/8	11/16
4 11/16	9 3/16	13 7/8	6 5/16	6	5/8	1 1/2	6	19 1/2	3	1 1/4	13/16
4 15/16	9 3/4	14 1/8	6 5/8	6	5/8	1 1/2	6 1/4	20 1/8	3 1/8	1 1/4	15/16

APPROVED PROPORTIONS OF FLANGE COUPLINGS

Should one read, and preserve what he reads? To take knowledge into one's hand temporarily, and then not afterward have that knowledge available for desired use, is as foolish as once to have seen a life preserver and not be able to find it at midnight collision.

Test of a Deutz Alcohol Engine

A short time ago at the General Electric Company's works, in Lynn, a test was made of a Deutz alcohol engine (made in Germany) that was to be coupled to a dynamo and sent to Cuba, where cheap Cuban alcohol—costing about 12 cents per gallon—will be used. The results of the experiments with the Deutz engine proved these three things: The combustion is clearer with alcohol than with gasolene; alcohol is suitable for use in motors even when it contains 15 per cent. water; and although a gallon of alcohol has fewer heat units than a gallon of gasolene, it develops about the same amount of power, because it can be compressed more without danger of premature explosion and less heat is lost in the exhaust gases and the heating of the water jacket. Most authorities agree that the efficiency of alcohol engines is prob-



Dia.	A	B	C	D	E	F	G	H	I		J	K
1 3/16	4 1/4	4	2 1/2	3 1/4	7/8	1	5/8	3/8	1 1/4	3/8	3/8	3
1 5/16	4 1/2	4 3/8	2 3/4	3 1/2	15/16	1 1/16	11/16	5/8	1 1/4	3/8	3/8	3 1/4
1 7/16	4 7/8	4 11/16	3	3 3/4	1	1 1/8	11/16	7/16	1 1/2	1/2	3/8	3 1/2
1 11/16	5 1/2	5 3/8	3 1/2	4 1/4	1 1/8	1 1/4	3/4	7/16	1 1/2	1/2	1/2	4
1 15/16	6 1/8	6	4 1/8	4 3/4	1 1/4	1 1/2	7/8	1/2	1 3/4	1/2	1/2	4 3/8
2 3/16	6 3/4	6 5/8	4 1/2	5 1/4	1 3/8	1 5/8	7/8	1/2	2	1/2	1/2	4 7/8
2 5/16	7	7	4 3/4	5 3/8	1 7/16	1 11/16	1	9/16	2	1/2	5/8	5
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2 15/16	8 5/8	8 5/8	6	6 5/8	1 3/4	2 1/16	1 1/8	5/8	2 1/2	5/8	5/8	6 1/4
3 3/16	9 1/4	9 5/16	6 1/2	7 1/8	1 7/8	2 3/16	1 1/4	5/8	2 3/4	3/4	3/4	6 3/4
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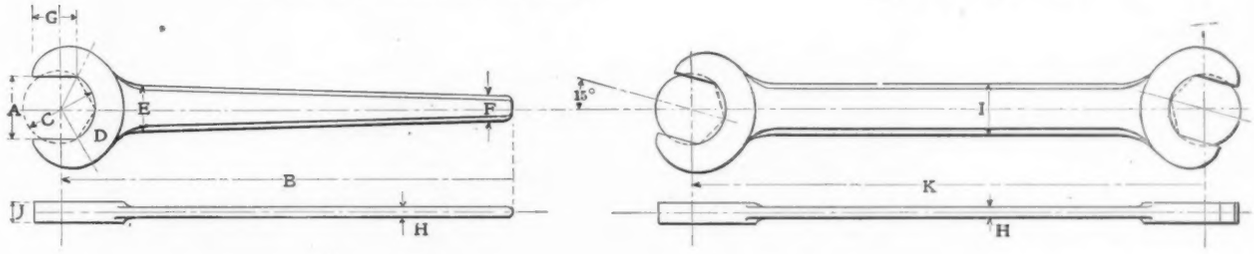
4 7/16	12 3/8	12 5/8	9	9 3/4	2 1/2	3	1 5/8	13/16	3 1/2	3/4	7/8	9
4 15/16	13 1/2	14	10	10 1/2	2 3/4	3 1/4	1 3/4	7/8	4	7/8	7/8	10

APPROVED PROPORTIONS OF CLUTCHES



Bolt	A	B	C	D	E	F	G	H	I	J	K
1/4	1/2	3 1/2	37/64	1/4	3/8	7/16	5/16	5/32	7/16	7/32	4
5/16	19/32	4 1/4	11/16	9/32	7/16	11/32	3/8	3/16	1/2	1/4	5
3/8	11/16	4 3/4	51/64	5/16	1/2	3/8	7/16	3/16	19/32	9/32	5 1/2
7/16	25/32	5 1/2	9/10	3/8	19/32	13/32	1/2	7/32	21/32	5/16	6 1/4
1/2	7/8	6	1	11/32	21/32	7/16	9/16	1/4	3/4	3/8	7
9/16	31/32	6 3/4	1 1/8	13/32	3/4	15/32	5/8	1/4	13/16	13/32	8
5/8	1 1/16	7 1/2	1 7/32	1/2	13/16	1/2	11/16	9/32	7/8	7/16	8 1/2
3/4	1 1/4	8 3/4	1 7/16	9/16	15/16	9/16	13/16	5/16	1	1/2	10
7/8	1 7/16	10	1 21/32	21/32	1 1/16	5/8	15/16	3/8	1 5/32	17/32	11 1/2
1	1 5/8	11 1/2	1 7/8	3/4	1 1/4	11/16	1 1/16	13/32	1 5/16	21/32	13
1 1/8	1 13/16	12 3/4	2 3/32	27/32	1 3/8	3/4	1 1/8	7/16	1 1/2	3/4	14 1/2
1 1/4	2	14	2 5/16	15/16	1 1/2	13/16	1 1/4	1/2	1 5/8	13/16	16
1 3/8	2 3/16	15 1/4	2 17/32	1	1 5/8	15/16	1 3/8	17/32	1 3/4	7/8	17 1/2
1 1/2	2 3/8	16 1/2	2 3/4	1 3/32	1 3/4	1	1 1/2	19/32	1 7/8	31/32	19
1 5/8	2 9/16	18	2 31/32	1 3/16	1 15/16	1 1/16	1 3/8	5/8	2 1/16	1 1/32	20 1/2
1 3/4	2 3/4	19 1/4	3 3/16	1 1/4	2 1/16	1 1/2	1 3/4	21/32	2 5/16	1 1/8	22
1 7/8	2 15/16	20 1/2	3 15/32	1 11/32	2 1/4	1 3/16	1 7/8	23/32	2 3/8	1 3/16	23 1/2
2	3 1/8	22	3 5/8	1 7/16	2 3/8	1 1/4	2	3/4	2 1/2	1 1/4	25

APPROVED PROPORTIONS OF WRENCHES

ably greater than that of engines using any other fuel for internal combustion. There may be some room for improvement also in this respect because of the newness of alcohol engines.—Arthur H. Bosworth, in *Yale Scientific Monthly.*

Chart for Carpenter's Separating Calorimeter

G. W. Bissell, professor of mechanical engineering at the Iowa State College, in the March number of the bimonthly publication of the engineering department of that college, presents a chart upon which the "iso-moisture" curves are laid out with the steam pressure and the time required to separate a given weight of moisture as ordinates and abscissas, respectively. In operation the time required to separate one-tenth of a pound of moisture is observed and the intersection of the line representing that time with the line representing the observed pressure will lie upon a curve or at a point between two curves representing the corresponding percentage of moisture.

Brown, Boveri & Co., of Baden, Switzerland, have on order a 15,000-kilowatt steam turbine for the Krupp works, in Germany. The overload capacity of this machine will be 18,000 kilowatts, involving the capacity to develop continuously 24,000 horse-power.

New Sewage Pumping Station at Chicago

Description of the Installation of the Thirty-ninth Street Pumping Station, on the South Side, Which Will Soon Be in Operation

BY ATHBURN W. MELTROSE

Of the two large pumping stations connected with the improved sewerage system for Chicago, Ill., the first which will be completed, and which is almost ready for operation, is that located on the lake front opposite the head of Thirty-ninth street, on the south side of the city. This is known as the "Thirty-ninth street pumping station," and is the subject of this article. The other station is situated at Lawrence and Evanston avenues, on the north side.

The purpose of these stations, which is twofold, is not to pump sewage into Lake Michigan, from which the city obtains its water supply, but to divert it from intercepting sewers which run parallel to the water-front into cross-town conduits, and to pump clean water from the lake into the same conduits, whence both sewage and lake water will flow, first, into a branch of the Chicago river, then into what is known as the "drainage canal," which empties into the Mississippi.

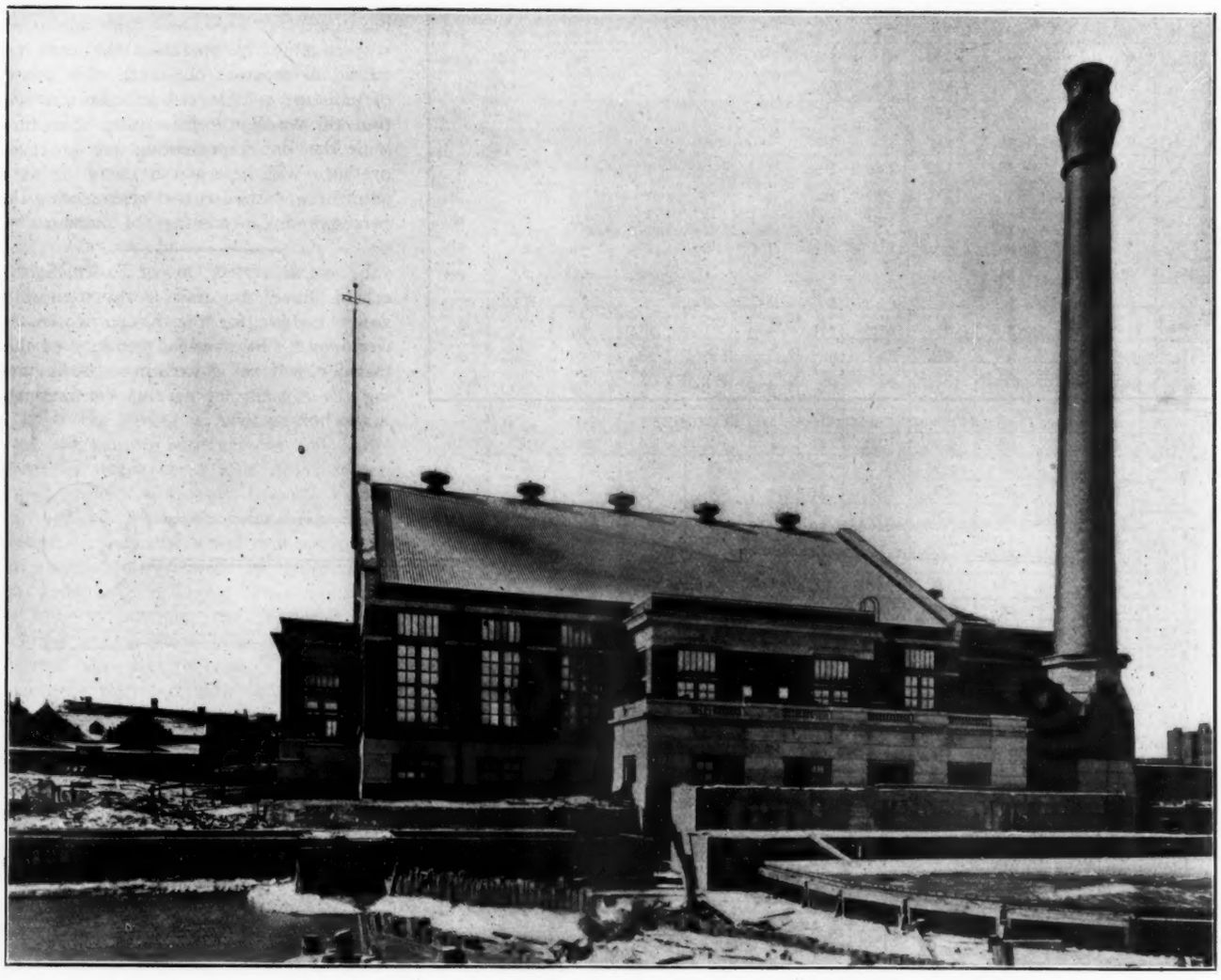
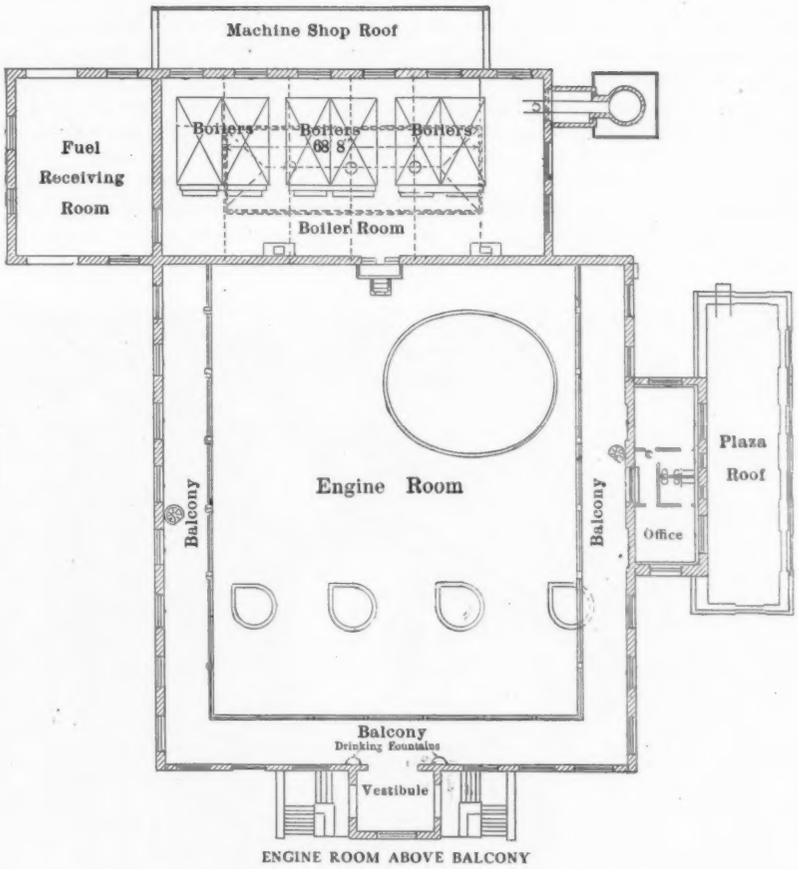


FIG. 1. NEW CHICAGO PUMPING STATION; NOTE CRIB-WORK OVER INTAKE

As the intercepting sewer which connects with the Thirty-ninth station is lower than the Thirty-ninth street cross-town conduit, the sewage has to be elevated into the conduit. The cross-town conduit served by this station is 20 feet in diameter. It is designed to deliver a minimum of 40,000 cubic feet of lake water and 7000 cubic feet of sewage a minute. The pumping station has a total capacity of more than 900,000 cubic feet of water a minute, afforded by four centrifugal pumps, two large and two small, and two screw or propeller pumps.

It was necessary to build the south-side intercepting sewer on a narrow strip of land between the right of way of the Illinois Central Railway and the lake, consequently the pumping station had to be built entirely outside of the bulkhead line, in water from 8 to 12 feet deep. That this was not an impossible feat may be seen by the general exterior of the building, as shown in Fig. 1, this view, which was taken from the water front, showing a part of the crib-work over the intake. A sea wall or breakwater was constructed



ENGINE ROOM ABOVE BALCONY

FIG. 2. PLAN OF 39TH STREET PUMPING STATION

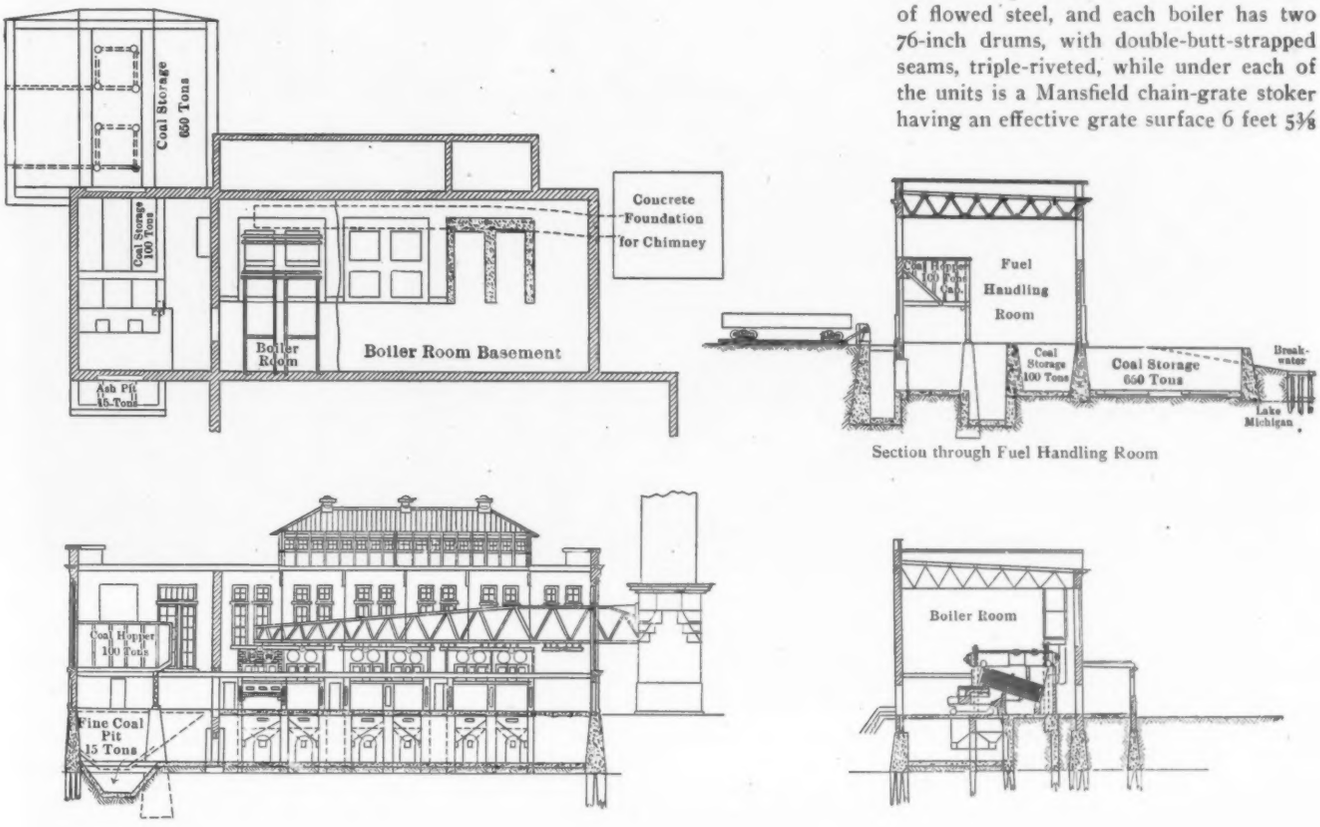
outside of the works. The building is constructed of brown, pressed brick, trimmed with Deer island granite, and covered with a steel-trussed tile roof.

Under the conditions, it may be surmised that the matter of obtaining a good foundation was not the easiest problem to be solved. A large coffer dam was built inclosing the site of the building, and the water was pumped out, laying bare the bed of the lake. The foundation was laid inside the coffer dam, without disturbing materially the position of the framing necessary to support the walls of the dam. The main building stands on a monolithic concrete footing, large concrete piers being carried down from the bottom of the main portion to a thick layer of hard-pan at a depth of 34 feet below mean lake level, this level being taken as datum.

The main machinery room, shown on the plan, Fig. 2, is 125x134 feet, with gate house, offices and convenience rooms on the lake side, and a 48x50-foot boiler-room at one end, while a 37x48-foot fuel-storage house adjoins the boiler room. In the front view of the boilers, Fig. 4, it will be seen that there are six units installed in three double settings. (This photograph was taken before the traveling chain grates and the track for supplying fuel to the stokers had been installed.)

The Boilers

The boilers are of the Aultman & Taylor water-tube type, and each has fourteen sections, having nine 4-inch by 18-foot tubes per section. The headers are of flowed steel, and each boiler has two 76-inch drums, with double-butt-strapped seams, triple-riveted, while under each of the units is a Mansfield chain-grate stoker having an effective grate surface 6 feet 5⅜



Section through Fuel Handling Room

FIG. 3. SECTIONAL ELEVATIONS OF 39TH STREET PUMPING STATION

inches wide by 8 feet long. The boilers are rated each at 264 horse-power, or a total of 1584 horse-power for the equipment. The stokers are fitted with the improved water back, and the ashes going over the rear of the grates will go through chutes in the concrete foundation piers to a conveyer located underneath the boiler-room floor in the basement. This ash-conveyer will carry the ashes out on the east side of the boiler house.

stack, which is 188 feet high above the footing, and which was built by the Alphons Custodis Chimney Construction Company, of Chicago. The stack rests on a concrete footing, 30x32 feet in plan and 15 feet deep, this footing being built on timber work laid on the tops of 100 piles driven to hard-pan. The base of the stack proper is of cut granite and brown brick to a hight of 36 feet, above which the outside is of radial pressed brick, with

boilers by a 6-inch connection tapped into each drum, the two connections for each boiler being joined by a tee to a 6-inch pipe that rises in a large expansion bend over the boiler and passes forward over the space in front of the boilers, then down by the wall separating the boiler and machinery rooms, to connect at the top of a 22-inch header running along the wall parallel to the boiler fronts, supported in position by brackets attached to

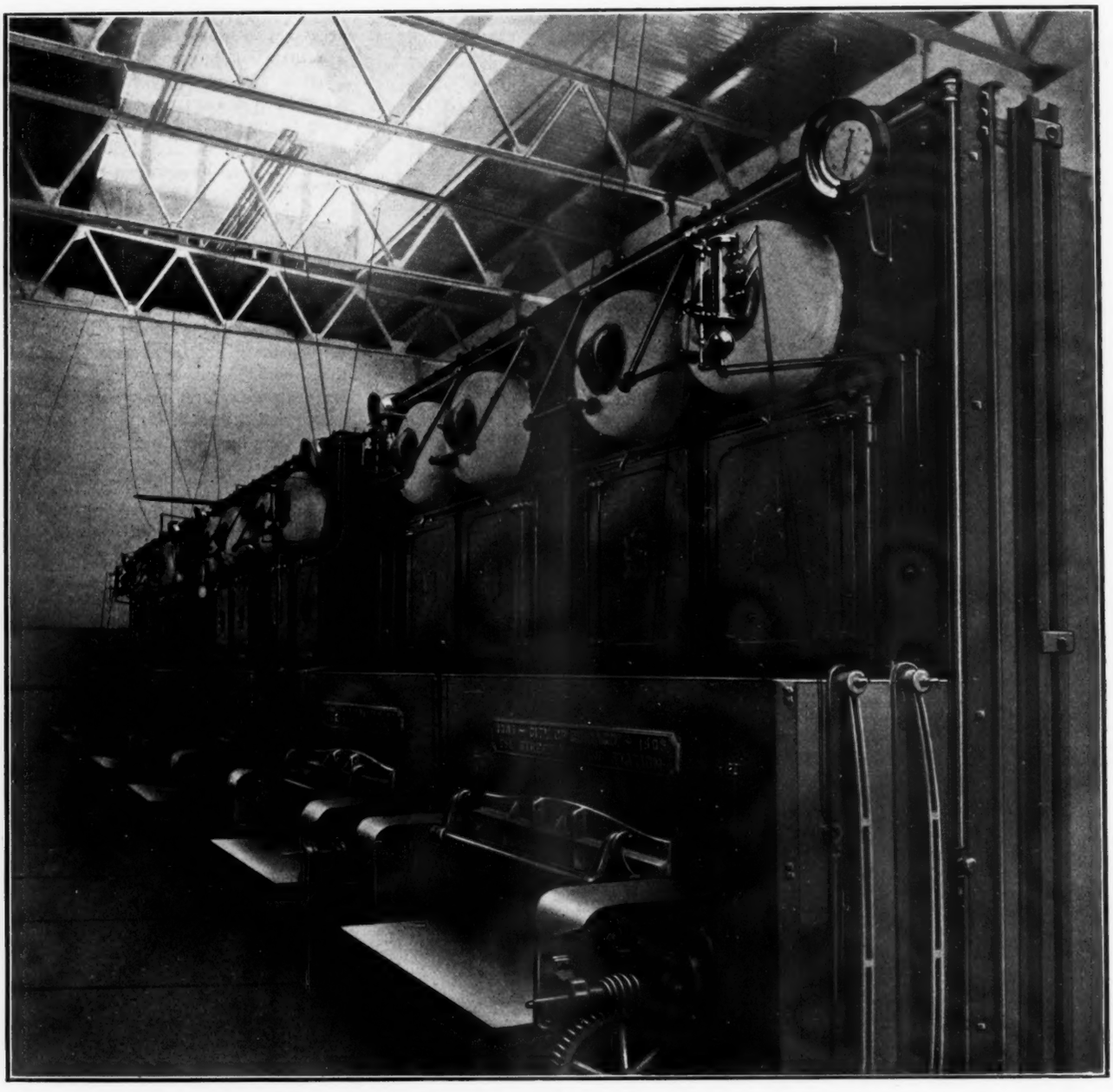


FIG. 4. VIEW OF FIRING FLOOR IN BOILER ROOM

In addition to the main boiler units, all the equipment in the boiler room, including the feed-water heater and auxiliary machinery, was made and installed by the Aultman & Taylor Machinery Company, which some time ago was consolidated with the Stirling Company, which has in turn become a part of the Babcock & Wilcox Company.

The uptakes connect to a radial brick

ornamental iron-collar trimmings near the top.

Feed-water for the boilers is taken from the lake and is supplied by two 14x8x16-inch, pot-valve, outside-end-packed plunger pumps furnished by the Union Steam Pump Company, of Battle Creek, Mich. The valves and seats are of bronze, being designed to withstand a working pressure of 300 pounds. Steam is taken from the

the wall. There is a nozzle connection on top of this header at the east end for a 10-inch pipe that supplies steam to two vertical screw pumps, and also to the two larger storm-water centrifugal pumps, the piping for this purpose running underneath the east gallery of the machinery room and being supported by brackets at proper intervals, while branches are taken off to the different engines.

On the other side of the steam header there is a connection for a 6-inch pipe that supplies steam to the two smaller centrifugal pumps. All the steam piping is interconnected so that steam can be supplied to each of the units by at least two different routes, thus enabling the plant to be operated in spite of any defect that might appear in any part of the piping system. The piping is covered with insulating material according to the best practice, and expansion loops are provided under the galleries at proper intervals to take care of expansion and contraction.

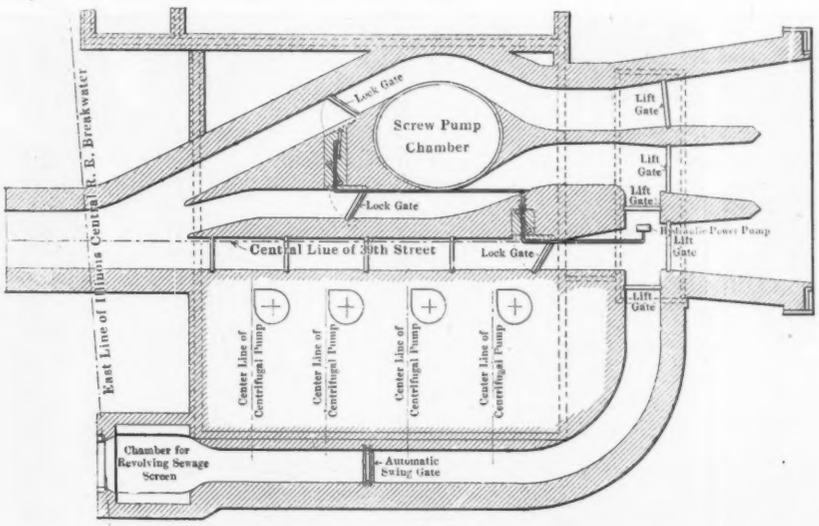


FIG. 5. PLAN OF BASEMENT

From Figs. 2 and 3 an idea may be had of the location of the machinery, but the location of the pumps is best indicated in Fig. 5, which is a plan of the basement showing the connecting channels from the pumps to the cross-town conduit. All of the pumps operate submerged, and the waterways leading to them are of concrete of massive proportions built directly on the hard-pan foundation.

The Pumping Units

The centrifugal pumping units are arranged in a row along one end of the machinery room. They are of the vertical type, with suctions from below, and the two smaller (Fig. 11) are designed for a capacity of 75 cubic feet a second each, being intended to pump the dry-weather flow from the intercepting sewer into the gravity channel that runs transversely across the building from the intake at the lake to a connection with the cross-town conduit. These pumps can also be used in connection with the two larger centrifugal pumps to pump the combined dry-weather and storm-water flow into the gravity channel. The capacity of the two large pumps is 250 cubic feet a second, and each of the four centrifugal pumps is direct-connected by a vertical shaft to a horizontal, triple-expansion condensing engine on the floor of the machinery room. Foundations here as elsewhere in the plant, are of monolithic concrete built up from the hard-pan, the engine beds of these four units being at a hight of about 45 feet from the bottom of the pits. The channels are of various forms in cross-section.

FIG. 6. ONE OF THE SCREW PUMPS

Connection with the intercepting sewer is made at the southwest corner of the building, the invert of the connection being 20 feet below datum. A 27x28-foot screen chamber is built in this connection just outside the line of the building, and beyond this a channel 12 feet wide, with its bottom from 21 to 23 feet below datum or 30 to 32 feet below the floor of the machinery room, leads along the end of the building for 130 feet to the corner on the lake side, where it turns 90 degrees and continues until it joins the gravity channel near its outer end. A sewage chamber with its bottom 23 feet below datum is formed in the outer channel beyond the screen chamber by a concrete wall built across the channel, and a heavy vertical automatic swing-gate, 11.5 feet wide and 20 feet long, is hung from the upper side transversely across the channel at this wall, so that it seats against a brass seat on the gate frame. This gate and the cross wall thus seal the sewage well from the inlet channel.

As the gate swings open away from the sewage well, it operates automatically during a storm, and admits the storm water flow to the intake of the pumps provided to handle it. The two smaller centrifugal units are at the shore end and handle only the dry-weather flow. The pumps of these units are in circular pits with the bottoms 19.5 feet below datum and 30.5 feet below the machinery-floor level, the center line of the discharge openings being 17 feet below datum. The

suction connection between each pump and the sewage well is built in concrete and has a 4x6-foot elliptical section at the well which changes to a 4-foot circular section as it approaches the bottom of the pump pit. At present the minimum quantity of sewage from the interceptor will be 25 cubic feet a second, and with this quantity flowing, the level of the water in the sewage well is 17 feet below datum. With the maximum estimated dry-weather flow of 148 cubic feet a second, the level of the water in the sewage well is 15 feet below datum, and the two smaller pumping units are required to work within this range in quantity and head under normal conditions in dry weather.

It is estimated that the combined flow of sewage and storm water may at times be as much as 666 cubic feet a second, and when the flow exceeds the capacity of the two small centrifugal pumps, one or both of the large units will be operated, as required. The normal service of the larger units is thus to elevate and discharge the combined sewage and storm-water flow occasionally, but they may be utilized also to pump lake water into the gravity channel. When the larger pumps are handling the flow from the interceptor, the lift-gate is closed at the end of the inlet channel where it joins the gravity channel, thus forming a main-pump well in the inlet channel extending from this gate back to the interceptor and including the sewage well.

The bottom of each of the pits in which the two larger pumps are placed is 9.5 feet below datum, and the suction connection of these pumps with the main-pump well is similar to the connection between the smaller pumps and sewage well, being 7x11 feet in cross-section at the well end, and 7 feet in diameter at the pump pit, where it is circular in section. To prevent backwater in the sewer from draining to the pumping station, it is necessary that the water level in the suction well be kept at least 6 feet below datum in time of excessive rainfall, and with lesser rainfall, to obtain the best practicable velocity in the sewer, the water surface must be kept at a lower level, depending on the quantity of the combined storm water and sewage flowing to the well. For these reasons the water level in the well varies from 6 to 14 feet below datum, but the

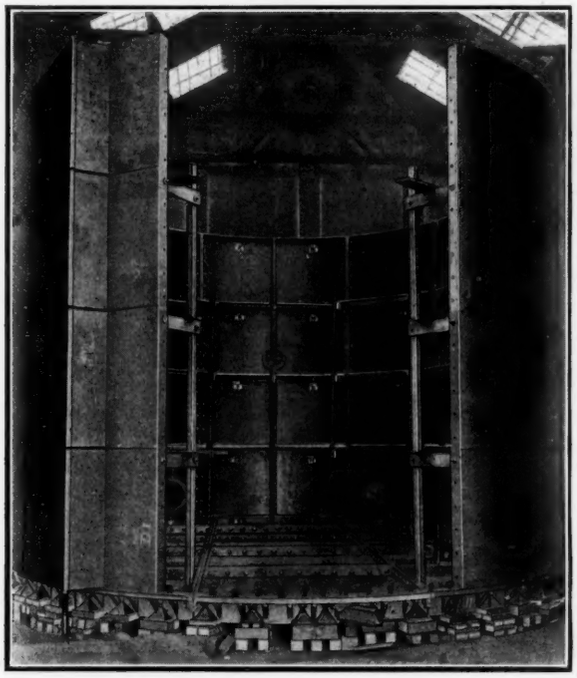


FIG. 7

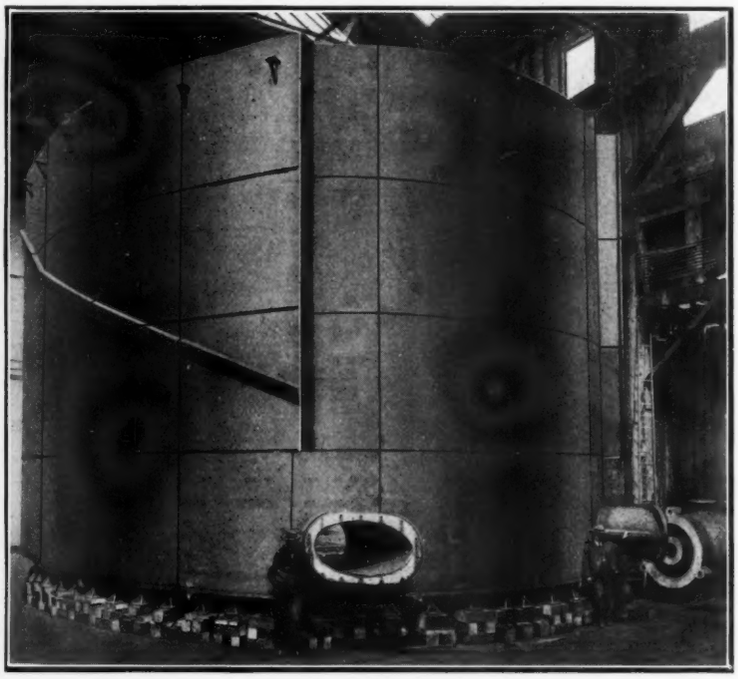


FIG. 8

ENGINE PIT AND LINING

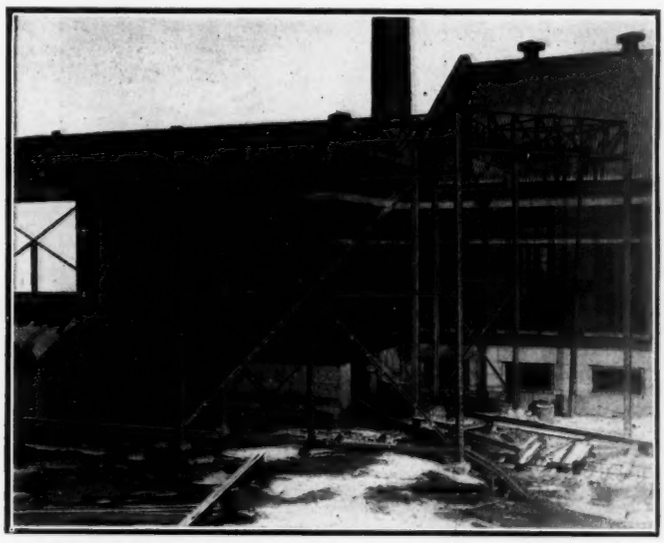


FIG. 10. SOUTH END OF COAL TRACK LOOP

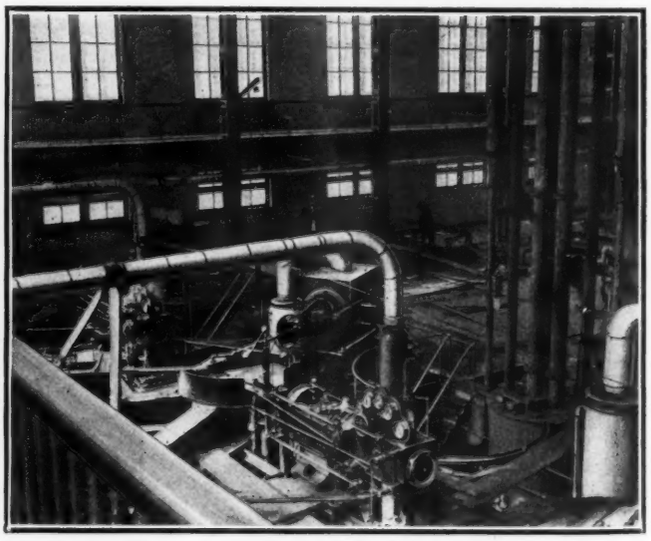


FIG. 11. VIEW IN ENGINE ROOM DURING CONSTRUCTION

greater part of the service to be performed by the larger pumps will occur when the level is from 11 to 13 feet below datum. The quantity pumped under these conditions will range from 100 to 250 cubic feet a second.

When the lift-gate controlling the connection between the inlet and the gravity channel is open, the swing-gate will remain closed and seal the sewage well from the rest of the inlet channel. When this lift-gate is closed and the larger pumps have lowered the water level in the main well between that gate and the swing-gate below the level of the water in the sewage well, if the latter level is above the top of the dividing wall, the swing-gate will open and the larger pumps begin to draw from the flow of the interceptor.

Under certain conditions, which may be considered normal since the opening of the drainage canal, the level of the lake is about 1.5 feet higher than the level of the river at the end of the conduit. For this reason, the conduit is laid so that a gravity flow from the lake to the river takes place through it. This flow, however, is not always equal to the required amount of water, and the deficiency is supplied by either or both of the screw pumps, which are set in concrete channels beneath the corner of the building diagonally opposite to that near the connection of the interceptor, with the inlet channel of the pump wells. The engines and the water channels for these two pumps are on the opposite side of the transverse gravity channel from those of the centrifugal pumps.

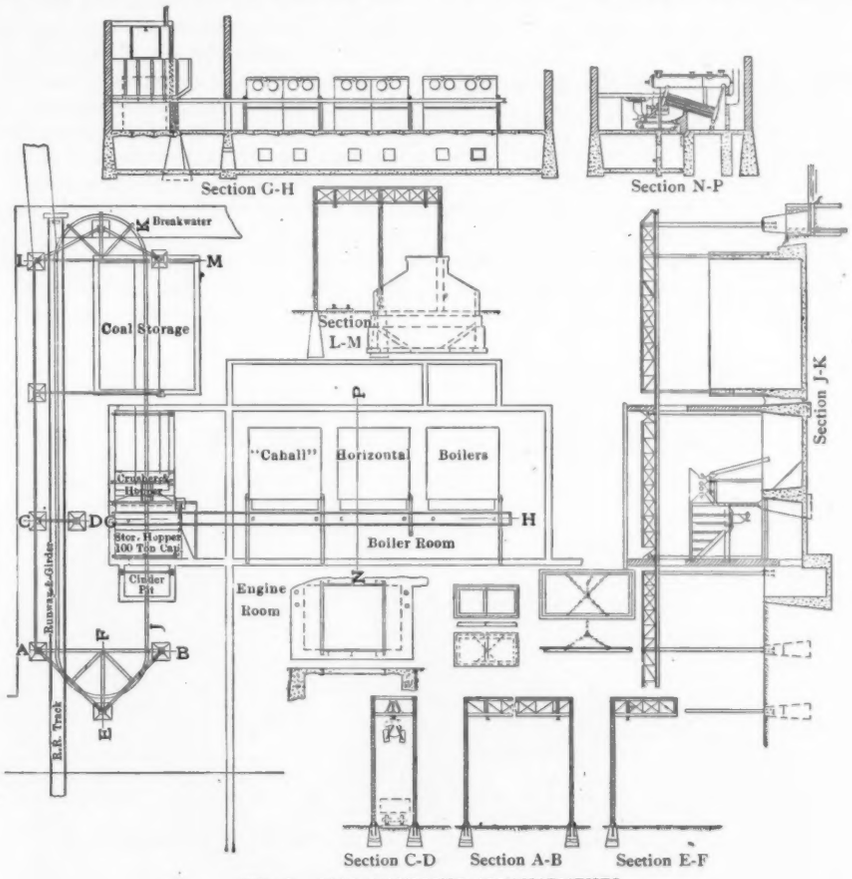


FIG. 9. COAL-HANDLING ARRANGEMENTS

Arrangement of Screw Pumps

Reference to Fig. 5 shows the arrangement of the channels connecting to the screw pumps, and Fig. 6 shows one of the screws in position in its channel. The screw is placed in a horizontal cylinder, 14.5 feet in diameter and 16 feet long, built up in concrete, the inverts of the cylinders for the two screws being 21 feet below mean lake level. The cylinders are flared out at both ends by raising their arches while the cross-sections of the channels leading to the intakes of the pumps and away from them to the conduit become oval as they approach their connection with the cylinders.

Each screw pump has a capacity of 666 cubic feet a second, and is direct-connected by a horizontal shaft to one of two vertical, triple-expansion marine engines, both of which are located in a cast-iron engine pit. As shown in Fig. 5, the engine pit is built between the waterways leading from the pumps to the conduit, and is oval in plan, the two diameters being 37 and 45 feet, respectively, and the depth 26 feet; the bottom is 14 feet below datum. The pit is built on 16 feet of concrete set on the hard-pan, and is floored and lined to the top with heavy cast-iron sections, as shown in Fig. 7, the metal of the lining altogether weighing about 320 tons. Fig. 8 is a view of the pit lining erected.

Each unit is independent of the other, and the waterways are separate, passing on opposite sides of the engine pit. In general arrangement and operation, these pumps and engines are similar to the machinery of a twin-screw ship, except that in this case the water moves past the stationary engines and screws, whereas in the ship the machinery moves relative to the water, which is practically stationary. Ordinarily the screw pumps will operate against a head of 7 feet.

As already mentioned, lake water comes to the pumps and the gravity channel through a horseshoe-shaped intake built out from the lake shore side of the main building. This intake is 80 feet wide at its junction with the gate-house and 80 feet long, from its outer end to the inner edge. It has a level concrete floor 20 feet below datum, supported on piers built up from hard-pan. The flat top is 4 feet above datum, and consists of a 4-inch plank floor, with open joints, supported on a grillage of iron beams carried by cast-iron columns that rest on bearing plates imbedded in the concrete floor, each incased in a wooden box.

Water enters through eighteen vertical wooden-slat screens, 11.25 feet wide and 14 feet high, spaced about equal distances apart in the sides of the intake, and in order to avoid as much as possible damage from the heavy ice gorges that are formed along the shore in winter, the intake is protected by a heavy breakwater. This structure consists of two rows of driven piles, the space between which is filled with stone. Since the heaviest jams of ice come from the north and east, the water is drawn through an opening in the south side of the breakwater, this opening being protected with clusters of piles.

Gates are provided for controlling the flow in the various channels, being placed beneath the station floor as indicated in Fig. 5. Channels lead direct from the intake to each of the screw pumps, as already pointed out, and the gravity channel extends out parallel to the two screw-pump channels to its connection with the intake. This gravity channel and the channel leading to the south screw pump, are connected on the lake side of the pump, the connection being controlled by a lift-gate which, together with the three gates in the channels, is controlled by the machinery in the gate-house. The channels leading from the screw pumps to the cross-town conduit are fitted each with a heavy lock-gate that swings horizontally on a vertical hinge in the concrete side wall. There are in addition four pairs of vertical guides for timber walls, which are arranged so that the water may be pumped out of the chamber that can be thus formed in front of any one of the centrifugal units, and this without interfering with the operation of any one of the other units.

Independent operation of the centrifugal pumps has been explained already, and should it become necessary to cut one or

more of these pumps out of service, the remaining ones toward the lake may be made to discharge into the conduit through the south screw pump and its channel. Each of the screw-pump channels connecting to the conduit is designed to work on a slight static head, while a free flow is had in all the other channels, so that they are simply floored over at the level of the machinery-room floor. The cross-section of the screw-pump channels changes from an oval to a rectangular shape and increases considerably in size just beyond the engine pit, this increase being had by raising the top of the channels, the inverts remaining at the same level or 21 feet below datum until the conduit is approached, where they rise about 1 foot. The under side of the flat top in the rectangular section, which continues for about 67 feet, is 8.5 feet above datum. The cross-section changes to a circular form as the gravity channel and the two screw channels approach the opening of the conduit, the top of the latter channels being brought down to datum again. A chamber is thus formed above water level in the screw-pump channels, which is more or less filled when the pumps are in operation, and a flow is thus induced through the conduit, depending in amount on the hight of the water in these chambers.

The Fuel-handling System

By casual inspection of Fig. 9, the plan for handling fuel can be understood without difficulty. It will be noticed that cars are switched on a spur of the railway under the loop that runs over and above the west end of the boiler room, and the coal-storage house. On this loop is a track carrying a car and elevating apparatus for lifting a grab-bucket which, after being lowered and picking up coal from the car on the railway track, is elevated by the hoisting gear; and the small car carrying the elevating apparatus and its attached grab-bucket full of coal is rolled around the elevated track to bring it into one of two dumping positions over the coal-storage house, or over a hopper in the end of the boiler house. The coal being dumped into this latter place is taken direct to the stoker hoppers in front of the boilers, the hopper containing it being mounted for this purpose on a four-wheeled truck that runs on an elevated track which passes across the boiler room in front of the stokers. The entire handling of coal, therefore, is done without hand work, and in case coal that has been stored in the house at the end of the main building is to be used, it is taken up by the grab-bucket as in the first place when the railway car was under the loop. It will be evident that the system is flexible in operation, and the fuel can be disposed of as may be desired.

Fig. 10 shows the south end of the loop structure, or that just to the south of the west entrance to the boiler room. On the easterly side of the building the elevated loop track passes over the boiler room at the extension on its west end, gaps being cut in the upper part of the building walls to permit the passing of the car with its bucket of coal.

The cost of building the two pumping stations and the cross-town conduits is borne jointly by the city of Chicago and the trustees of the sanitary district, and the work of construction was carried on by the city, but the system will be maintained and operated by the sanitary district. W. A. Shaw is engineer in charge of the work, and N. A. Sager, assistant engineer in the intercepting sewer division, was immediately in charge of the construction of the station. All of the pumping machinery was furnished by the Allis-Chalmers Company, Milwaukee, Wis., and the gates were built by the Hansell-Elcock Company, of Chicago.

Catechism of Electricity—XXV

Portable Alternating-current Voltmeters

508. *Can voltages on alternating-current circuits be measured by the direct-current voltmeters previously described?*

They cannot, because the current in the coil would "alternate" rapidly and tend to pull the coil first one way and then the other. The result would be no deflection of the pointer.

509. *Do all alternating-current voltmeters operate upon the same principle?*

No; there are several forms of alternating-current voltmeters based on different principles of operation. Among these are movable-coil or "ironless-field" voltmeters, hot-wire voltmeters, and inclined-coil voltmeters.

510. *Explain the principle upon which movable-coil voltmeters operate.*

In this meter there is a fixed coil in two sections, and a movable coil, connected in series. In Fig. 119 *m* and *n* represent the two sections of the "ironless"-field coil, and *c* denotes the movable coil. The sections of the fixed coil are wound in the same direction on hollow non-magnetic bobbins and serve in place of the permanent magnet used in the direct-current voltmeter. The movable coil is connected in series with the stationary coils and its spindle carries the pointer *p*. The movable parts comprising the coil *c*, the pointer *p*, and the springs attached to the top and bottom of the spindle are of practically the same construction as those in the direct-current voltmeter previously described. In the "ironless-field" instrument here described, no matter in which direction the current flows, the attraction or repulsion between the magnetic lines of force generated in the movable coil and those in the field set up by the coils *m* and *n* always tends to deflect the pointer *p* in the same direction. This is due to the fact that the fixed coils and the movable coil are connected in series, and when the current changes direction in one of them it changes direction in all three, thus preserving the same magnetic relation between them. An instrument of this type may be used to measure either a direct- or alternating-current voltage.

511. *Should any corrections be made for changes in temperature?*

Yes, but they are applied automatically by means of the rheostat *x*, Fig. 119, which is graduated between 60 and 100

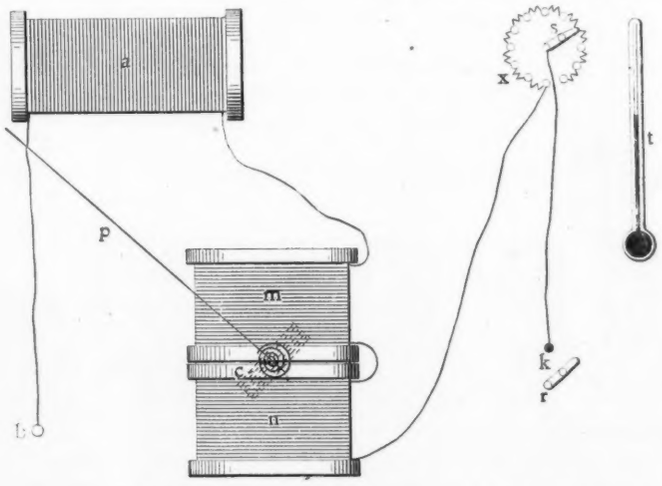


FIG. 119. INTERNAL ARRANGEMENT OF IRONLESS-FIELD VOLTMETER

degrees, Fahrenheit. Before taking readings of voltage, the temperature of the surrounding air is noted on the thermometer *t*, and the pointer *s* of the rheostat is turned to the mark corresponding to this temperature. Sufficient resistance is thus cut in or out of the voltmeter circuit to compensate for the change in the working resistance of the meter due to a change in temperature.

512. *What is the general appearance of a movable-coil voltmeter for measuring either alternating- or direct-current voltages?*

Fig. 120 shows an exterior view of a two-scale voltmeter of this type. The upper scale is graduated to 150 volts and

may be used by connecting to the terminals *a* and *c*, while the lower scale, graduated to 75 volts, may be used by connecting to the terminals *h* and *c*. The high-resistance coil of this meter is divided in two sections and connected as in the case of the two-scale direct-current voltmeter previously shown. The key is denoted by *k*, the thermometer by *t*, the compensating rheostat by *x*, and the scale by *s*.

513. *What is the principle upon which hot-wire alternating-current voltmeters operate?*

The hot-wire instrument depends for its operation upon the expansion of a fine wire strip of conducting material due to the heat produced by the passage of the current to be measured. The indications are proportional to the square of the current, because the heating effect varies as the square of the current. Both alternating- and direct-current voltages can be measured with a hot-wire instrument.

515. *Illustrate and describe the construction of a hot-wire voltmeter.*

Fig. 121 and 122 show, respectively, interior and exterior views of this instrument. A long piece of platinum silver wire 0.0025 inch in diameter passes up and down the long tube *B*, Fig. 122, over pulleys supported in this tube. One end of the wire is fixed to the small brass block *m*, Fig. 121. Thence the wire is led around one of two grooved pulleys *b* and *d*, supported by a ring at the bottom of the tube. (In Fig. 121 the bottom of the tube is brought close to the head in order to keep the drawing within limits.) From this pulley the wire returns and is passed around a small pulley *c*; thence it is led around the second pulley *d* and finally terminates at the small brass block *n*. The brass pieces *m* and *n* are supported

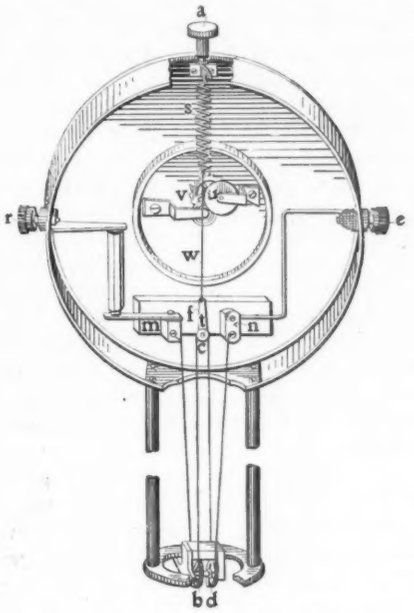


FIG. 121. HOT-WIRE VOLTMETER

by the block of insulating material *f*, which is fastened to the case of the instrument; *m* and *n* are connected each to one of the binding posts *r* and *e*, which are insulated by fiber collars from the brass casing. The small part *c*, referred to as a pulley, acts as such only during the wiring of the instrument, in order to facilitate equalization of the tension in the two halves of the wire; the expansion of the wire when the apparatus is subsequently used does not cause this pulley to rotate. It is fixed by a small screw passing loosely through its center to one end of a thin brass strip *t*, the other end of which has attached to it a fine platinum wire *w* connected to the spiral spring *s*. The tension of this spring, which can be varied by means of the adjusting screw *a*, keeps the wire taut. When the main terminals *r* and *e* are connected to points in a circuit at different potentials, a current passes, say, to the block *m*, then through the entire length of the four stretches of the expansion wire to the block, *n*, and thence to the other terminal *e*. This current heats the wire, which expands, and the slack is immediately taken up by the spiral spring *s* so that the small brass strip *t* and the wire *w* are moved through a distance equal to the expansion of two lengths of the heated wire.

515. *How does this expansion show the voltage of the current passing through the wire?*

Through the medium of a jeweled watch movement. The wire *w* is led around a small pulley *u*, Fig. 121, fixed upon the same spindle with a toothed wheel *v*, which gears into a small pinion the spindle of which carries a long pointer *p* passing over a graduated dial in Fig. 122. When the wire is expanded by the current, the spring *s* causes the pulley *u* to turn through a small angle, and with it

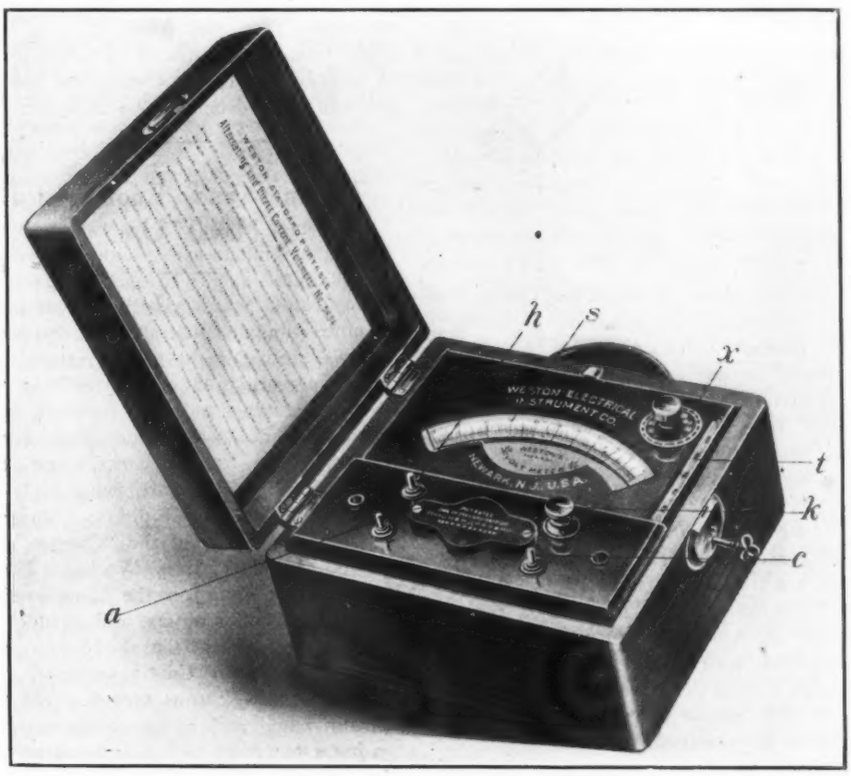


FIG. 120. PORTABLE IRONLESS-FIELD VOLTMETER

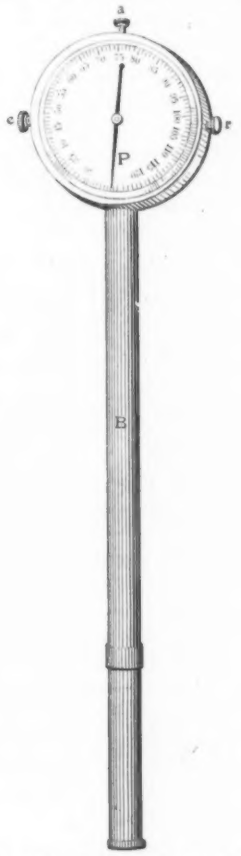


FIG. 122. HOT-WIRE VOLTMETER

also the wheel v; the pinion and the pointer are turned by the wheel v, and as the diameter of the wheel is much greater than that of the pinion, the pointer is turned through a large angle by a comparatively small expansion of the wire. A

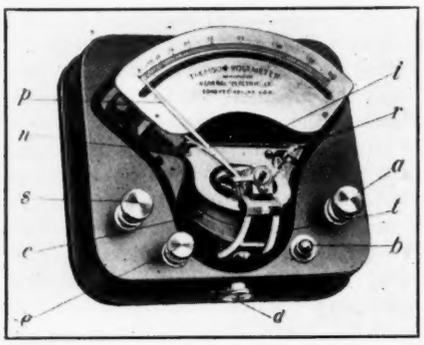


FIG. 123. INCLINED-COIL VOLTMETER

long, fine wire is used in preference to a shorter one of greater sectional area, because the fine wire heats and cools much more quickly than a larger one would, thus making the instrument more nearly dead beat. By introducing extra resistance the capacity of the instrument can be increased.

516. *Does the hot-wire voltmeter possess any disadvantages?*

It does. Since the meter depends upon temperature differences for its operation, it is extremely sensitive to variations of external temperature, and such variations must be compensated either by increasing or decreasing the tension on the working wire or by providing auxiliary heating strips. Another disadvantage is the constant change of the zero point, due to the failure of the wire to return to the same point after a measurement, on account of a slight residual strain. Still another objection is the large current required to operate the meter, rendering it ineffectual for delicate testing.

517. *Show the working parts of an inclined-coil voltmeter and describe the principle of operation.*

The working parts can be seen from the interior view, Fig. 123. They com-

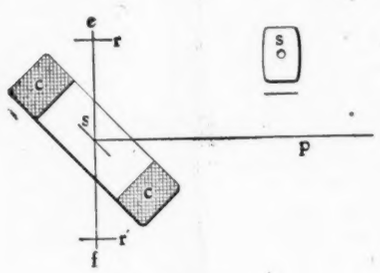


FIG. 124

prise the inclined coil c wound in two sections for the high and low reading scales, these sections being connected between the binding posts a and s, and between a and e. The coil c is inclined about 45 degrees and held in position by an iron support t well insulated from it. This support also contains the bearings for the movable part and the flat spiral springs attached to the top and bottom of the same. The movable part consists of an oblong piece of soft sheet iron s, Fig. 124, mounted on the spindle $c\,f$ at an angle of 45 degrees. The pointer p is also attached to this spindle, and at such a position with respect to the sheet iron s that when the pointer is at zero the sheet iron will lie in the plane of the inclined coil $c\,c$, as shown in Fig. 124. When voltage is applied the lines of force produced by the current in the coil pass through its center, tending to turn the sheet iron s so as to lie at right angles to the plane of the coil $c\,c$, as in Fig. 125, and deflect the pointer over the scale. In both Figs. 124 and 125 r and r' represent flat spiral springs at the top and bottom of the spindle.

518. *For what are the buttons* b *and* d, *in Fig.* 123, *provided?*

Referring again to Fig. 123, there may be seen at n a frame, across the top of which is stretched a cord i, the whole being supported by a rod at r, which can be given a vertical movement by pressing the button b. At the bottom of the guide for the rod r is a spring which keeps the frame and cord raised and out of contact

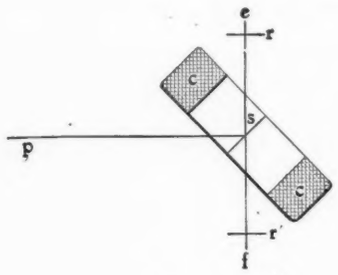


FIG. 125

with the pointer p when the button b is not depressed. If, however, the button b be pressed down, the cord i will be pressed against the pointer, which travels horizontally between the frame and the cord, thus stopping its vibrations. The button d serves for closing the circuit through the meter.

519. *Are the vibrations of the pointer in alternating-current meters much more noticeable than in direct-current meters, when taking measurements?*

They are, and for this reason the majority of alternating-current meters are provided with some form of damping device to stop the vibrations of the pointer and thus enable a reading to be taken within a reasonable time after the circuit through the meter has been closed.

The City Council of Peoria, Ill., has under consideration an ordinance to supplant the Board of Examining Engineers by a board which shall consist of one engineer, one boiler maker and one machinist.

A Suction Gas Power Plant to Burn Bituminous Coal

It is announced that a suction producer plant of 2000 horse-power, to burn bituminous coal, will be installed in the Anderson, Ind., works of the Nicholson File Company. The equipment is to be supplied by the Industrial Gas Company, New York, and will supply gas to an existing equipment of engines that have been running some time on natural gas. The engines will be altered to suit the new conditions of operation.

The generator is to be of the simple up-draft type; it will deliver the gas to a wet scrubber, where it will be washed with water; thence the gas will pass to a rotary washer, designed by Gustav Saaler, of Germany, and said to be capable of eliminating practically all the tar and soot brought over from the wet scrubber. This rotary washer will be driven by a 50-horse-power steam engine, and will maintain a pressure of a few ounces at the delivery outlet of the entire producer plant. The gas will pass finally through the usual dry scrubber or purifier; no holder will be used.

The plant is to be installed under guarantee to gasify 2800 pounds of Indiana coal per hour, producing gas of not less than 140 B.t.u. per cubic foot (reduced to 62 degrees temperature) and containing not more than 0.01 grain of dust per cubic foot, 0.005 grain of tar, 0.15 grain of sulphur, 4 grains of moisture nor 15 per cent. of hydrogen (by volume).

Turbines and Engines for Naval Use

The United States navy will enter upon an interesting demonstration of the comparative merits of the steam turbine and the reciprocating engine, as well as the two leading types of steam turbines, with the putting into commission of the three similar scouts, the "Salem" and the "Birmingham," which are being built by the Fore River Ship Building Company, of Quincy, Mass., and the "Chester," by the Bath (Me.) Iron Works. These boats will be built on the same model, have similar boiler outfits, and be alike in every respect except that the "Salem" will be equipped with Curtis turbines, the "Chester" with Parsons turbines, and the "Birmingham" with reciprocating engines, the horse-power of each boat being 16,000. The "Salem" will have two shafts with a Curtis turbine upon each. The "Chester" will have four shafts with a high- and low-pressure Parsons turbine upon each of two of these, and a cruising turbine upon each of the other two. Their comparative performance will be watched with interest.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Automatic Devices for Speed Control

In ye olden times a steam engine equipped with a governor built to meet the conditions seldom raced to the point of running away. The engine of the past has been improved, and the art of governing reduced to such nicety that the most rigid exactions of specifications are met by builders. With all the improvements of the past twenty years, however, there were many more fly-wheel explosions in 1906 than in 1905. The result of the adoption of automatic devices by engine builders goes to prove the contention of many consulting engineers that the governor may fail.

Nearly all the automatic devices applied by engine builders have been designed on the theory that the governor should perform some part of the work of shutting off the steam, as when the breaking of a belt allows the balls to fall and operate a knockout, or the falling of a rider on the governor belt operates the hooking arrangement or closes the ports. The secondary governor and various forms of quick-closing valves have been brought into use, also, and still the work of destruction goes on. What is the matter? The engine builder has achieved wonders all along the line of engine building, but has failed sadly as an engine-stop builder. The engineer who has designed a stop that is nearly perfect for his engine cannot apply his device to all classes of engines.

The trouble can be traced to different sources. First, the builder has clung to the governor and purely mechanical devices; second, the user of engines has not been willing to pay for devices recommended by the builder. It is forgotten that governor balls do not always fall quickly enough, that, in fact, they frequently stick at a point that holds the ports open, and, therefore, the governor helps to wreck the engine. How can we control the engine of the twentieth century? I emphatically say: With the best type of governor; but when the control fails there must be some way to limit the speed until the controlling device is in working order again. I make bold to say to engine builders, engine owners, and engineers—*don't* try to do this by any action or lack of action, on the part of the governor, for it cannot be done as it ought. It should be done by an independent device made of few parts, strong, reliable and so simple that it can and will be used by the engineer to stop his engine, without having to go near the throttle. The mechanic of the twentieth century can make a perfect mechanical device for this purpose; the builder of electrical apparatus can make the electrical portion so perfect as to leave no excuse for its being out of order, and the engineer who lets it get out of order deserves to lose his position.

The electrical equipment for speed-limit devices should be made with great care, and then installed with the same care. The electro-magnets should be carefully wound and armored in such a way as to be free from grounds, or liability to ground. The terminals should be soldered to spring clips for holding the wires. There should be some simple method of testing through all the closers in one circuit, for the introduction of annunciators to denote where the circuit is closed tends to defeat the principal feature of a speed-limit device. With a one-loop circuit there will be only the operating magnets in circuit, therefore the chances of failure are reduced to a minimum.

The test board should be of slate or marble, and need not be more than 6x8 inches and 1 inch thick. On this should be mounted the binding springs for the wires, a single-strap spring key with platinum contacts to operate the stop mechanism from a distance, a double-strap key with platinum contacts, and a pair of high-resistance magnets or an ammeter introduced into the circuit for a test. All wires on this board should be highly insulated, and all joints and connections soldered. The speed-limit device should have platinum contacts and spring clips, in place of binding screws, so that the jar may not work the wires loose. Circuit closers should be made with spring clips for holding the wires, or a long copper sleeve. If the wire is doubled and forced through this sleeve, with the end of the wire turned over so that the set-screw becomes lost, the contact will still be good.

The wires should enter the speed-limit device through an iron-armored conduit held firm by check and bushing nuts. There should be an arrangement at the operating magnets for holding the conduit firm, and the conduit should be used wherever there is danger of dirt or mechanical injury. Open work is desirable on ceilings and walls away from injury, and the wires should be fastened to porcelain knobs or cleats; where they go through floors or partitions, porcelain tubes should be used. All joints should be long and soldered.

Have the device installed by first-class mechanics and electricians, and the result will be an automatic engine-stop and speed-limit system that will protect the engine from racing at all times, and one that will be highly indorsed by engineers, consulting engineers and engine builders.

F. S. PALMER.

Battle Creek, Mich.

Says Mr. Porter Was in Error Regarding the Allen Valves

In one of Mr. Porter's "Reminiscences," which I have mislaid, he gives an account of the alterations to the last steamer of the E. K. Collins lines, the "Adriatic." His description of Horatio Allen's cock-valves and their motions is absolutely correct; but when he says they would not work (under steam, he means, for they worked very well when *cold*), they were replaced by Stevens valves and the Stevens cut-off, he is in error. The writer made the greater part of the detail drawings by which the new valves and the Sickels cut-off were placed on the "Adriatic," and he was on board the ship the day the engines revolved for an hour or two, without accident, under steam. Horatio Allen was there at the same time, with his 10-year-old son. Our office then was at 56 Wall street, and all the drawings were made there. To show how easily Mr. Sickels' new reversing roller-link for poppet valves worked, Mr. Allen's little son stopped and re-started that pair of great oscillators (100 inches bore by 12 feet stroke) without a hitch in the operation.

Mr. Allen regained possession of the vessel, and tried to maim the new machinery, but was not successful, although he badly mangled the device for adjusting the cut-off by hand. I went to the Novelty Works and warned him that his valve could never be revolved when hot, because of its double-metal construction—and so it came to pass.

Paul Stillman built a model for exhibition under steam, and that, being all one metal, worked well, four motions and all. I thought it a good valve, if a judge of

metallic expansion had designed it. He had an 80-horse-power one made, all iron; that went well; but why did he insert a valve face of brass? That was his ignorance and his overthrow.

PETER VAN BROCK.

Jefferson, Iowa.

"Troubles Caused by Faulty Piping Work"

Regarding H. A. Jahnke's article on the above subject in the May number, page 296, I would suggest that the writer of that article does not appear to make proper provision for the expansion and drainage of his steam lines. In his Fig. 10 the arrangement could easily be made far more efficient and reliable by substituting a bend of good radius for the ell shown on the left-hand boiler; in fact an ell should not be used in this position at all. When the pipe joining these two boilers begins to expand, something will happen, and that will most probably mean that either the ell or the tee will be broken.

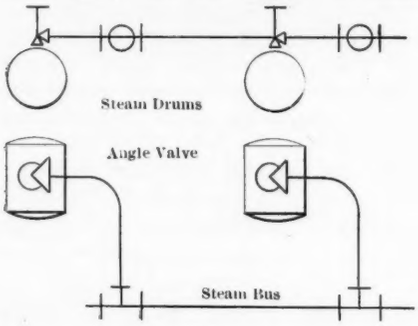
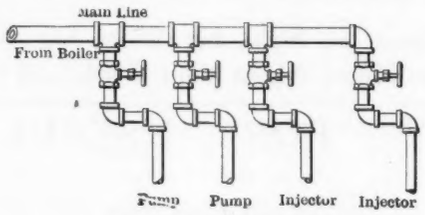


FIG. 1

Mr. Jahnke's suggestion as to placing the stop-valve against the steam drum is right enough, but he omits to mention that provision must be made for draining the vertical leg next to the valve. This could easily be arranged by tapping the elbow on its bottom side. A much better arrangement, however, would be to use angle stop-valves placed immediately on top of the steam drums, with the steam pipes running horizontally, as in Fig. 1 herewith. Even if it is necessary to take the steam from the end of the steam drum, as shown, the branches may still be taken horizontally toward the bus-pipe. This would prevent water accumulating on top of the stop-valve, as would certainly happen if connected up as shown in Mr. Jahnke's Fig. 10. If the branches are connected as shown in Fig. 1, it is a simple matter to efficiently drain the bus-pipe.



MR. JAHNKE'S FIG. 11

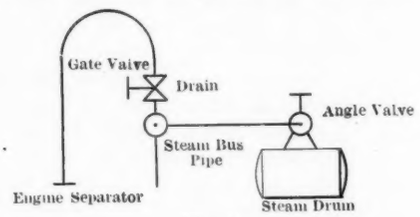


FIG. 2

The branches from the bus-pipe to the engines should be taken either from the top, as in Fig. 2, or in the same horizontal plane, as in Fig. 3. The latter is preferable, perhaps, as it saves draining above the valve seats, when the engine is provided with a separator. With bends of easy radius from the boilers and to the engines, the bus-pipe may be easily and flexibly suspended, all troubles due to an expansion being taken up by the bends.

With long bus-pipes it becomes necessary to insert expansion pipes and these should be preferably of the shape shown in Fig. 4, erected, of course, with the loop horizontal. If space will not permit, then the expansion pipe may be erected with the loop on top, but means must then be provided for efficient draining either by tapping off both sides of the loop or connecting a small drain pipe to carry the water along, as in Fig. 5. Various forms of this expansion pipe are in use. Where space is very limited there may be used as an expansion joint a short piece of pipe sliding in another through a bushed joint. These, however, give a great deal of trouble through leaking.

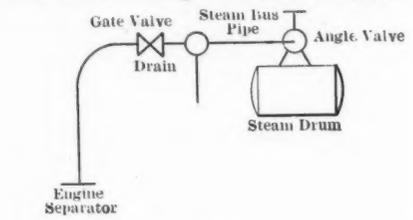
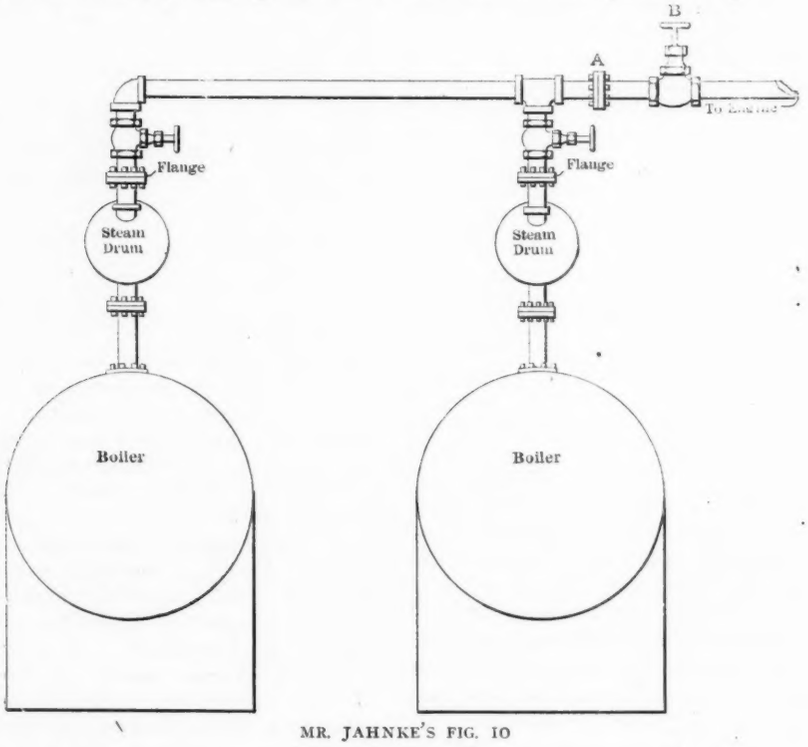


FIG. 3

In Mr. Jahnke's Fig. 11, if, as I believe, this shows an elevation of the piping, he is likely to have trouble with his pump cylinders due to water being forced into them immediately upon opening the stop-valve. This can be overcome by running branches horizontally from the bus-pipe and efficiently draining the bus.

W. VINCENT TREEBY.

Kent, Eng.



MR. JAHNKE'S FIG. 10

FIG. 4

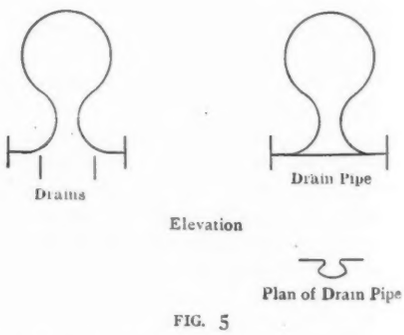


FIG. 5

Internal Separators

Advertisements pertaining to internal steam separators are on the increase, and the question arises in my mind, are these separators built according to theory, or is the idea practical? One separator which has been on the market for a number of years is built something like that shown in section in Fig. 1, *A*, *B*, *C* and *D* being

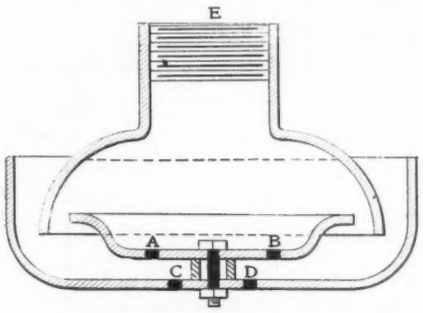


FIG. 1

holes to allow the water to escape, while the part *E* is threaded and screwed on to the steam outlet.

Another form appears to be something like Fig. 2, so far as I can judge from an illustration at hand. Steam enters at holes similar to those at *A* and *A'* (the holes extending completely around the device), and impinges on *D* and *D'*. At

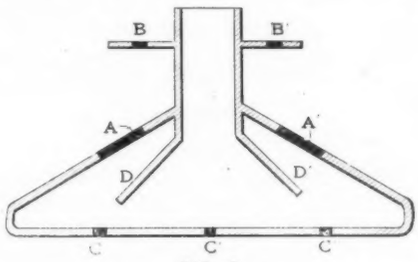


FIG. 2

C, *C'* and *C''* are holes to allow the separated water to drain back, and *B* and *B'* are holes through which bolts pass into and through the boiler shell, to hold the separators up to the steam outlet in the boiler.

The designer of the separator shown in Fig. 3 claims to have obtained his ideas from Fig. 2, and also from an outside separator in which a number of plates are

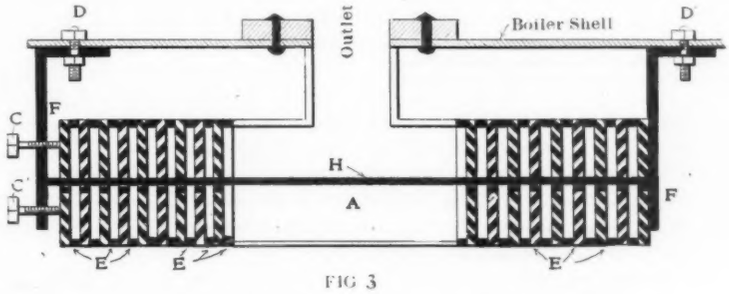


FIG 3

used. This one resembles in shape, and somewhat in construction, an internal-mesh separator which is made by a New York firm, but as its method of separating the water is different I will describe it. As will be noted, each opening on each plate is at an angle. As the steam rushes in at *F*, it passes obliquely through the first plate and impinges on the next,

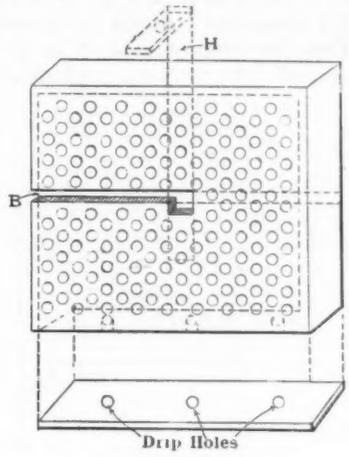


FIG. 4

and so on (as the holes are not opposite each other), and any water which may become separated will run down and escape at *E*. The operation is continued at each plate until the steam reaches *A*, when it should be perfectly dry. The bolts *C* and *C'* are used to tighten up the plates, and at *D* and *D'* are bolts through the boiler shell to hold the separator in place.

Fig. 4 is a view of one of the cast-iron plates. Each plate is slipped on to the binding and supporting bar *H*, from side to side alternately, so that the openings *B* will not be opposite each other on any two adjacent plates. None of these last mentioned separators has been made; it is simply an idea.

JAMES E. NOBLE.

Toronto, Ont.

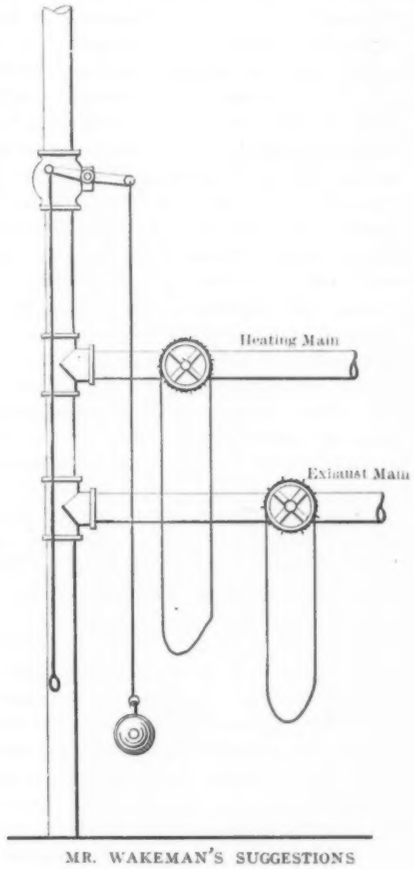
"Weighting a Back-pressure Valve"

In the June issue James G. Sheridan presents a plan for handling a back-pressure valve. He favors the idea of locating the weight high above the engine-room floor, so that when it comes off it may injure somebody. Another objection to it is that when the valve is held open by hooking the chain down, it is equivalent to having two weights on the slender lever, which is not necessary. Neither of these objectionable features appears in my original article on this subject in the November POWER.

He shows a way to prevent climbing up to his back-pressure valve, but according to his illustration he must climb up to open the valve in the heating main, and be could change the weight on the back-pressure valve at the same time.

I present herewith an illustration of what I believe to be an improvement over his plan. Only one weight is used, with no hook to represent another. When the valve is to be opened the weight is suspended from one loop, and when it is to be closed it is simply changed to the other loop, and both of them are near the floor.

In a certain plant where I was employed I wished to avoid climbing a ladder to put on steam, so I had several small forgings made in the form of a letter V, with a flat bottom. Taking off the large cast-iron wheel, I had one of these riveted on the rim for each spoke in the wheel. By the use of a small rope carried two or three times around what was then a grooved wheel, it was possible to open and close the valve without going up to do it. This plan is also shown in the accompanying illustration. If the valve-stems are vertical, and it is not convenient to change them, the small rope may



MR. WAKEMAN'S SUGGESTIONS

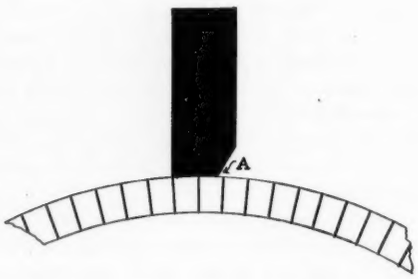
be carried over two carrier pulleys, and it will work just as well, for I have tried it.

W. H. WAKEMAN.

New Haven, Conn.

"What Causes the Dynamo to Spark?"

I have solved the problem which I submitted under the above caption, and which was published in May POWER. The commutator had worn down so that the



WHAT CAUSED THE DYNAMO TO SPARK

brushes covered three segments. The remedy was merely to cut off the tips of the brushes, as at *A* in the sketch herewith.

H. B. BRAND.

Brooklyn, N. Y.

On page 395 of the June number H. B. Brand asks, "What causes the dynamo to spark?" It would be practically impossible to answer a question of this nature intelligently without more data as to load, style of machine, type of brushes, etc. If the dynamo is overloaded and is running with ordinary carbon brushes slipped through a holder, with only spring tension, they will spark and heat also. If this is the case, they should be fastened "pigtail" by leading a flexible, stranded copper conductor from the brushes to the main leads. Drilling into the brush, inserting the "pigtail" and wedging it firmly is good, but driving wedges too tight will split the carbon. See that the brushes are set diametrically opposite each other, spacing with a paper strip being the most accurate way. Keep the brushes as near the commutation point as possible, and be sure they fit perfectly.

A variable load on one of the old-style bipolar dynamos will cause sparking, unless one stands at the brush quadrant and shifts the brushes to the proper commutation point with each change of load. Otherwise, a series coil might be added to the field and a compound machine made of it. This is assuming, of course, that it is a plain-shunt machine. If the brushes are properly fitted, set and "pigtailed," the load fairly steady and the armature O. K., the machine ought to run fairly well. A broken lead in the armature will cause sparking, but in this case will burn one particular commutator segment more than the others, and show just where the trouble lies.

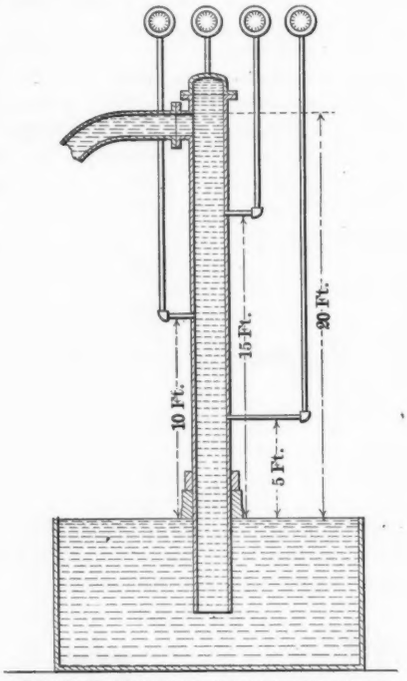
J. E. BATES.

Greenacres, Wash.

Loose Parts and Narrow Escapes

On page 161 of the March number W. H. Wakeman writes of two narrow escapes from disaster due to loose parts. In this connection I submit the following:

When the piston-rod is in its proper place and the check-nut tightened up, paint a narrow strip across the nut and rod, with black or white paint, as at *A* in the sketch herewith. If this is done the rod or nut cannot get loose without the engineer noticing it.



EFFECT OF LOCATION ON VACUUM GAGES

To detect a loose piston, place your hand on the rod at *B*, when just starting up, and if the piston is loose on the rod the vibration will reach the hand before the noise of the pound reaches the ear.

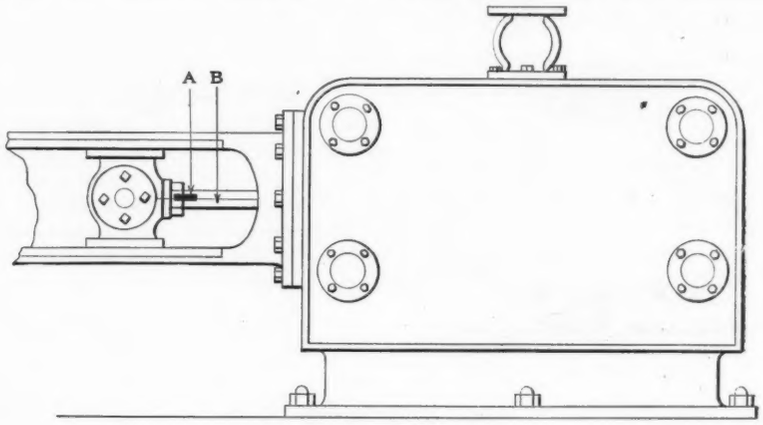
To tell the difference between a pound in the crosshead and one in the crank, flush the crank with oil and if the pound stops, tighten up on the crank-pin brasses; if not, try the crosshead brasses.

THOMAS SHEEHAN.

Adams, Mass.

Effect of Location on Indication by Vacuum Gages

A recording vacuum gage is connected to the sucton pipe of a 5,000,000-gallon Gaskill pump, six feet below the discharge valves; but the gage pipe is extended two feet above the discharge valves. Will the gage show the correct lift?



HOW TO DETECT LOOSE PARTS

Herewith is a sketch of a suction pipe with vacuum gages attached at different places. Will all of the gages indicate alike?

R. B. HENDRON.

Wichita, Kan.

A Steam Plant without a Chimney

The illustrations which embellished my article on the "Trials of Engineers in the Early Days," beginning with the April number, are very spirited, and seem to go to the heart of the matter; but they remind me of an incident in my earlier career, which is almost too good to let pass.

I had been engaged to take care of the mechanical engineering in connection with the construction of a large water-works plant in the West; and while discussing with the manager the various features of the work, he called my attention to a water-color perspective drawing of the proposed new pumping station, which, nicely framed, hung on the wall of his office.

It was a very handsome looking structure of cut-stone, with a noble tower, but there seemed something lacking, and it was some time before I could determine just what was missing. When it dawned upon me, I asked him what he was going to do with the smoke from the boiler furnaces.

"What do you mean?" said he.

"There is no chimney," I replied, at which he declared that he had not noticed the lack of it. He told me afterward that he asked the architect why he had left out one of the most important features

of a steam plant, and the architect replied that "a chimney would spoil the looks of the picture."

I do not imagine for a minute that you had any better reason for the omission, but will let it go at that, if you will publish this to act as a sort of shelter for me to crawl under.

ALONZO G. COLLINS.

Philadelphia, Penn.

Examiners' Questions to Engineers

The following are samples of questions asked by three different examiners of engineers:

FIRST EXAMINER

1. What are the dimensions of the walls for two 72-inch by 18-foot boilers?
2. What is a slide-valve engine?
3. What is a Corliss engine?
4. How would you take up lost motion on a crank-pin?
5. How would you shut off the steam from a low-pressure heating system?
6. Name all the valves in the returns of a low-pressure heating system.
7. How would you start and stop a 1200-horse-power compound-condensing Corliss engine, the conductor being direct-connected?
8. If during the day you were asked to shut down for a minute or so, explain how you would do it.

SECOND EXAMINER

1. If you were installing two boilers, one a vertical and the other a horizontal tubular, which would you carry the highest pressure in, and why?
2. Why is a safety plug put in the horizontal tubular? Take it in the vertical boiler, the tops of your tubes are exposed. Why should there be any more danger in one than in the other? The gases travel just as far in one as in the other.
3. Where is the O. G. in a vertical boiler and what is it for?
4. Name the valves in rotation in the feed-pipe from the feed-tank to the boiler.
5. If your feed-pump was feeding your boiler all right, and you switched it on to an open tank to fill it up and you found it would not pump any water, what would be the trouble?
6. Why are duplex pumps used for condensers?
7. Why are jet condensers made pear-shaped?
8. How would you set the valves of a Putnam engine?

THIRD EXAMINER

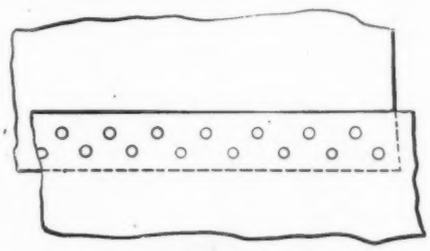
1. What is the area acting on the longitudinal seam of a horizontal tubular boiler? Take a boiler 4x10 feet.
2. Is it possible to get the girder seam weaker than the horizontal seam?
3. Point out where you would look for flaws and cracks in a joint like that shown in the accompanying cut; which plate and at what side?
4. If you were to look into the crank-case of a Westinghouse compound engine, would you see a large and a small piston?
5. How would you reverse a Westinghouse engine?
6. If your shaft governor did not respond quickly to a change in the load, how would you fix it?
7. Where would your steam eccentric be set in a double eccentric engine in order to cut off at 5/8 stroke?
8. If your initial pressure was 100 pounds, cutting off at 1/4 stroke, what would be your terminal pressure?

THOMAS SHEEHAN.

Adams, Mass.

Too Much Draft

Recently I heard a story of trouble with a battery of Babcock & Wilcox boilers and was asked the cause. These boilers were originally fitted with a low stack and induced draft, the fan of which was sufficiently powerful to lift small coal off



ILLUSTRATING A QUESTION BY AN EXAMINER

the grates. Later the owners were induced to install a well-known type of steam blower, and shortly after this installation there commenced to be trouble. A large number of the headers broke open, tubes cracked and the boilers seemed to have gone to general decay. The fractures of the tubes showed crystallization and appeared twisted, so ruptures were looked for at any time. Buckwheat coal was used for fuel and the use of steam blowers for that fuel has been too extensive, and in too many cases without injury, to lay the trouble to that alone; for, while the burning of the small amounts of hydrogen from the decomposed steam may make a little hotter fire than from a fan blower, it is not the heat that makes trouble, but apparently the cause of the twisted and crystallized tubes is unequal expansion. The question is, how did the unequal expansion occur? I explained to the owners that the induced draft was much too large for the boilers and, when running at full speed, would draw in cold air from all sides, brickwork and all. Being so strong, the draft would burn out a fire in a short time, and then the amount of cold air that would go through the grates would be something prodigious.

At times men reason that to make steam they must use draft, but the amount of draft is not considered as long as the steam is not too high. They find it easier to put or keep on air draft than to pay close attention to the fires. I have found that this was the case in the case under discussion. They had made it a practice not to allow the throttle valve on the fan engine to be opened more than one-quarter of a turn, so that, should the pressure-regulation valve open wide, the fan could not run so as to produce excessive draft. I suggested that after the blowers were put in, the fan engine should have been run only enough to take the gases away, and possibly not at all. I was told that the steam could not be kept up with the blowers alone, and that the fan had to be used.

The results shown would indicate that the operation was something like this: Steam would get a little low and the fires would be put in good shape with the blowers on, and probably the induced draft, and on top of this the throttle would be opened wide. So long as the steam kept up, no further attention was paid to the fires, which soon burned low, and with both blower and draft open wide would cool down the iron. Then hot fires would be built again.

It is wonderful what strains iron and steel will sustain from unequal expansion, yet it is not strange that the metal sometimes gives out. Often hot fires are built and allowed to get low with the full draft on; water is turned into the boiler with the feed valve wide open, and this water soon turns cold, on account of the heater not being large enough. Then this strong feed soon checks circulation and unequal expansion is set up, both from the difference in temperature and the difference in the weight of the water within the boiler. In fact, I might enumerate a great variety of common practices that tend to the destruction of boiler material.

W. E. CRANE.

Boston, Mass.

Device for Adjusting Crank-pin Brasses While in Motion

Would a device whereby the crank-pin brasses of an engine could be adjusted while the engine is in motion be of any practical value to the profession? I have made such a device which works nicely upon my engine and can be used on any engine having a wedge and one bolt for adjusting the brasses. Should like to know how much of a demand exists for such a device, and what difficulties it is likely to encounter in practice.

A. CHARTER.

Hornbeak, Tenn.

Simple and Effective Fly-wheel Repair

The accompanying sketch shows where a crack occurred in the hub of a four-foot fly-wheel of a 12-horse-power hoisting engine, and how it was repaired. The crack extended from the keyway, as at *A*. A steel band *B* was shrunk on to the hub to prevent the crack opening, and the repair proved to be as efficient as it was simple.

E. E. W.

Prescott, Ariz.

SIMPLE FLY-WHEEL REPAIR

"The Ideal Internal-combustion Engine"

I have read with much interest E. N. Percy's article in the July number, page 443, on "The Ideal Internal-combustion Engine." Having done considerable work in developing what I consider to be the ideal form of internal-combustion motor, the confirmation by Mr. Percy of many of the ideas I have worked out is very gratifying. There is no question in my mind but that the engine of the future will be of the "injected-fuel" type. The advantages of this system are so numerous that it is remarkable that such an engine has not been placed on the market before this. With this type there can be no pre-ignition, the governing mechanism is much more simple, no igniters need be used, except in starting, and no carbureters need be used in liquid-fuel engines.

Mr. Percy has omitted to mention a very important point in his ideal engine, however, and that is, the combustion chamber and that part of the cylinder in which expansion takes place should not be water-jacketed, but a non-conducting material should be used, so that the heat of the fuel cannot escape from the burning charge. Mr. Percy realizes the loss here, and while his method is advantageous in returning in steam the heat which will unavoidably go to the water jacket, the method which prevents the escape of the heat in the first place is much better. I have a number of engines running on this system, the combustion chamber being kept hot and the water jacket being fitted only to that part of the cylinder in which the piston slides. The water-jacket loss in these engines is quite small compared with the loss in the ordinary type.

I have worked out a system for large engines in which considerable heat now wasted will be returned to the cylinder. The water from the jacket is taken through a small governor-controlled pump through a very long coil of tubing in the exhaust pipe, the water entering at the end farthest from the engine. The pressure in the tube may be from 200 to 400 pounds, and before the water reaches the engine end of the tube it will be converted into steam at a corresponding pressure by the heat from the exhaust gases. By this system it should be possible to discharge the exhaust gases at a temperature of, say, 300 to 400 degrees, which is much less than the present practice. It would not pay, however, to install this system on small units owing to the increased complications. It will be noted that with this arrangement the amount of water passed through the jacket and injected into the cylinder varies with the load, which is as it should be.

I believe with Mr. Percy that the two-stroke-cycle engine will be more and more used in the future. The inlet and exhaust valves, cams, springs and push-rods of the four-cycle engine, together with its lonely impulses every two revolutions, must in the end give way to the simplicity of the two-cycle with its doubly frequent power strokes.

The objectionable features of the two-cycle explosive-mixture type are entirely non-existent in the injected-fuel type. Only air is taken into the cylinder when the exhaust is open, and if any escapes no loss of fuel occurs; there can be no crank-case explosions, when no fuel is mixed with the air; and as air only is required in the cylinder proper in starting there will be absolutely no trouble through having improper mixtures.

I have now under construction a three-cylinder vertical 5x5-inch two-cycle self-starting and self-reversing crude-oil engine, combustion chamber not water-jacketed, automatic ignition when running, the fuel being injected at the end of the compression stroke by compressed air. A two-stage air compressor is mounted on the crank-case and driven from the crank-shaft to supply air for spraying the fuel and starting and reversing the engine.

This engine uses the crank-case for compression, but for engines of, say, 10-inch diameter and upward, I should inclose the lower end of the cylinder, using it as a pump, and have a crosshead and piston-rod instead of a trunk piston. This construction would eliminate a great deal of wear on the cylinder, leave the bearings open and get-at-able, and allow the fresh air to cool the cylinder and piston.

This two-cycle double action is certainly much to be preferred over the double-acting four-cycle cylinder with its water-cooled piston, piston-rod, stuffing-boxes and multiplicity of valves and cams. It is unlikely that any cooling would be necessary in the two-cycle piston, and as the pressures would not exceed about 5 pounds in this end of the cylinder, the stuffing-boxes would be easily arranged.

As regards the compression pressures used, I am inclined to think that 200 pounds is as high as it is safe to go with our present materials and knowledge. With 200 pounds compression pressure there is a possibility of reaching over 600 pounds maximum. This requires a fairly heavy engine, and the economy gained by carrying the compression above this point would be counterbalanced by the increased cost of the machine.

I am dubious, as yet, about the rotary compressor or the turbine principle, except, perhaps, for very large installations, but this feature is not essential to the proposition.

The compressed-air starting mechanism is the ideal arrangement for internal-combustion engines, and works out particularly well with a three-cylinder two-cycle engine. This type will start from any position without boring and will reverse as positively as a steam engine. I am looking forward to the time when many of our large vessels will be equipped with this type.

An engine built with a hot combustion chamber, as above noted, can be run on any cheap grade of crude or fuel oil and will develop power much more cheaply than the steam engine in all cases where oil can be had at reasonable rates.

A 200-horse-power four-cycle engine with hot combustion chamber developed power, on test, at the rate of two-thirds of a gallon of fuel oil per 10 horse-power-hours. The compression pressure used in this engine is about 150 pounds.

The ideal engine should embody these features:

(1) Fuel injected at the end of the compression stroke.

(2) Combustion and expansion chambers not water-jacketed.

(3) Two-stroke cycle.

(4) Automatic ignition after starting.

(5) Compressed-air starting gear (and reverse if required).

(6) Steam at high pressure injected into the combustion chamber in large engines.

(7) Compression pressures up to 200 pounds per square inch.

(8) Governing by controlling fuel feed.

H. Addison Johnston.

Toronto, Can.

A Tin Can Makes a Good Boiler Float

A common tin can (aside from rusting) will make a first-class float in a boiler, provided water is put into it and it is properly sealed. Take a steam table, find the weight of the volume of steam at and above the pressure it is intended to carry in the boiler, put into the can about one and a half times the amount of water necessary to make that volume, solder up the can and throw it into the boiler. The next time the boiler is cleaned the can will not be found to have collapsed, but it will still be there, although the tin may be all gone. I had to laugh when the idea first occurred to me, but I tried it and proved the theory.

P. M. KNOPP.

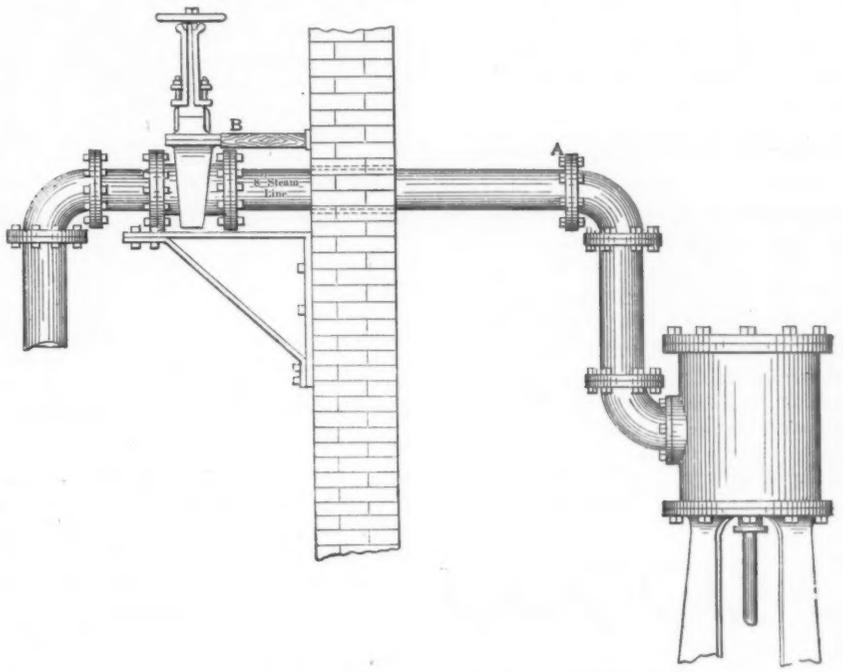
Kansas City, Mo.

Leaky Flange Joint, and How Remedied

The accompanying sketch shows a vexatious condition which confronted a fellow engineer shortly after he took charge of a fair-sized plant. The flange union *A* on an 8-inch steam line not only refused to stay steam tight, but when the nuts were removed the sections sprang apart about an inch. The cause was found on the other side of the wall where a brace *B* had been located to prevent vibration of the line, but which tended to force the pipe out of true. The remedy was found by drilling a small hole in the wall, inserting a rod clamp on the line and removing the brace. That joint has not leaked since.

J. BURNS.

Columbus, O.



HOW A LEAKY FLANGE JOINT WAS REMEDIED

A Fable with a Live Moral

"A penny for your thoughts, Jim," said I, as I leaned on the end of the cylinder. "I see you've taken an indicator diagram. My! but she runs dandy—never used to run like that before you came; the boss is tickled to death. I just passed the office door and heard him talking to Ramsey. He said: 'That fellow Jim is certainly a scientific engineer. Why, just look, Ramsey, my bills are away down to what they used to be. We're using less coal under the boilers, getting more steam and not a leak in our one-mile steam line. Then look at the engine and boiler room since that genius came. It's a revelation. I really am surprised that we went on the way we did. I'm not a bit sorry that we invested the money in improvements—it's paying us; everything is so clean and systematic now it is hardly possible to soil a white handkerchief. Have you noticed the big crowd of visitors we are having lately? That engine room is a great ad for us. And then the oil; the bills used to be terrific, you know. Now we have no waste, since using the latest filters and patent lubricators.

"'It really was laughable, Ramsey, the first day Jim came. Remember how he shut down the plant, threw out the old packing, and said if he was going to run here I'd have to buy the best packing? Of course, I kicked on the price, but, great smoke! I see it now. We're only buying one case where we used to buy two. Jim's the most practical engineer I ever came across. He's death on getting his copy of POWER every month. He says he attributes his great success as a stationary engineer to the invaluable suggestions, advice and instruction in it. Not only does he feast upon the reading matter, but he devours the advertisements, which, he claims, are little gold mines for those who want to save money.

"'One thing more I don't mind telling you, Ramsey, I am paying Jim's subscription to POWER now; and when Jim's not using it, I wish you would go through the ads carefully each month, just as if you were itemizing a bill, and take notice if there's anything offered that we haven't got that will reduce our running expenses in the end. Never mind the first expense; get the thing, and *get it quick*.'"

"Well, that was quite a story; but I guess it's true," said Jim. "I was just thinking back, when you came in, of the time I first started to work in an engine room. I was just about your age, but in those days we didn't have the appliances to help us along that we have now—no water gages on the boiler, but we had to measure the water with a stick. That makes you laugh. Those were the days of the old-time valves. If they opened, the puzzle was to get them closed. It wasn't so much of a trick to start the engine, but sometimes it was fun to stop her. The good old bygone days, when the valves wouldn't valve, the *eccentric* was clean crazy, the cut-off stayed off, and the exhaust line blew enough steam to run a battleship. But things have changed step by step. In the old days, instead of the engine running, it used to be the engineer that did the running. Now we're in a scientific age when, we might say, a new valve is born every little while, and if a stranger steps into a modern up-to-date engine room he is astonished. The governor at last really governs; but the question is, what runs it? You see a pipe leading to the cylinder—but find the steam, that's it. No noise, heat subdued by pipe covering, terrific power manifested by majestic and almost silent motion are the results of invention and science in the engine room. How different from the old engine room! When you went to look for the engineer, somebody would tell you that he was in back of that cloud of steam. All you could hear was a terrific din, and above the noise you would yell, 'where's the engine?' You would be told: 'It's in back of the steam, too, along with the engineer; he's running the engine. When he shuts down you'll see him.' This little reminiscence puts me in mind of two engineers' boys who were boasting of their parents. Said one boy: 'My pap is a better engineer than yours; just look at the noise my pap's engine makes.' But enough! Here's the mail man with another copy of POWER."

J. J. GOUGH.

Pittsburg, Penn.

Who Can Explain This Phenomenon?

The other evening while attending a lecture I was greatly interested in the following phenomenon. The lecturer was depicting air waves, by means of a stereopticon, and among the illustrations were a series which showed the, to me, peculiar action of six balls, each sustained on a flat spring, as shown in Fig. 1. The balls and springs were very small, but the same results would be obtained if they were large.

The operator drew one of the balls back, as in Fig. 2, and then released it, with this result: The four middle balls, Fig. 3,

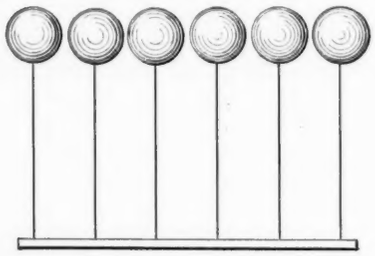


FIG. 1

swung back and forth together, while the end balls swung each by itself. When two balls were drawn and released, the force set the balls vibrating again, but with altogether different results. Instead of the four in the center vibrating together, the balls paired up into groups of two each, as shown in Fig. 4. When three balls were drawn back and released, two groups of the three balls each were formed, as in Fig. 5, the members of each group swinging or vibrating together.

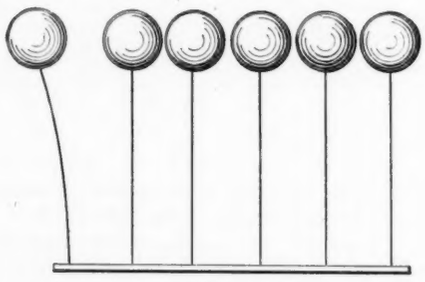


FIG. 2

When four balls were drawn back and released and grouping again changed and four balls formed one group, while two balls formed the other. This is shown in Fig. 6. When five balls were drawn back the result was different from what was expected, as the grouping was the same as that shown in Fig. 3.

Who can explain why these balls grouped themselves as they did? It is a matter concerning which I have not been able to get a definite, or even an indefinite, answer.

INQUIRER.

Cleveland, O.

How Does Superheated Steam Affect Fittings?

I have heard it stated that superheated steam has a corrosive, possibly solvent,

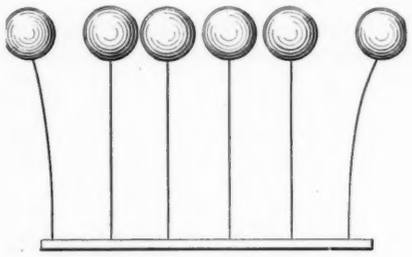


FIG. 3

effect upon cast iron, less effect upon iron and steel mixtures, and scarcely any effect upon open-hearth steel castings; whence the only thing to do is to wait several months for steel castings.

Now I submit that we all ought to know something about the habits of this "high-temperature bug" and would suggest that some of our operating friends, preferably those who have seen the inside of fittings which have been acted

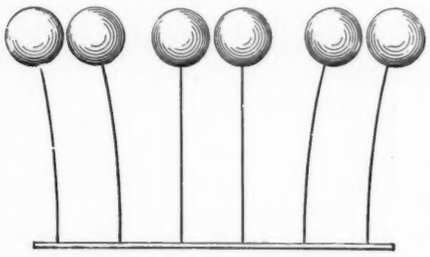


FIG. 4

upon for some time by superheated steam at a temperature of 100 degrees or more above saturation temperature, and who have their imaginations well in hand, communicate the results of their observations so we may be enlightened.

E. L. BROOME.

Boston, Mass.

A Pointer on Brush Setting

It is common practice in setting the brushes of motors or generators of the

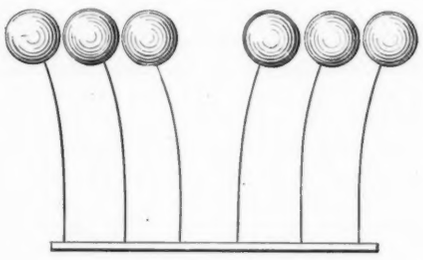


FIG. 5

multipolar type to stagger the brushes so as to have them cover nearly the whole length of the commutator segments and prevent ridges forming between the brushes. Generally the operator will set the first positive set of brushes out from the commutator head, and the next negative brushes in toward the head, and so on, causing the brushes to trail each its kind. While this method gives the quadrant a very neat, uniform appearance, the results will be very much better if a positive brush trails a negative.

BURTON B. PIERCE.

Mansfield, O.

Repairing an Eccentric-rod

Figs. 1 and 2 show a temporary repair on the valve stem of a 10-horse-power vertical automatic engine which is used to drive the dynamo to supply light for

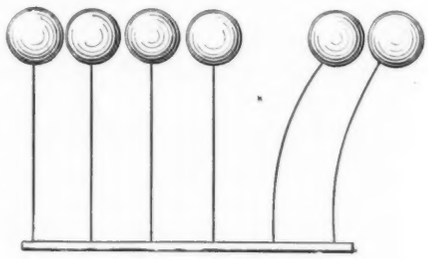


FIG. 6

a lumber company here. One night, for some unexplained reason, the eccentric strap ran hot, and as it was a pretty snug fit it seized on the eccentric and snapped the rod off close to the eccentric lock-nut, at the point *A*, Fig. 1.

As this happened in the winter, when lights were required during several hours each day, it had to be fixed before morning. There were the usual right- and left-hand threads on each end of the rod with a hexagonal part *B* close to the eccentric end for adjusting the rod.

To repair it, the lock-nut was filed

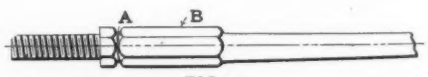


FIG. 1.

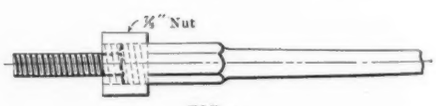


FIG. 2.

down and made round, and a ⅞-inch die was run over it. This was the worst part of the job, owing to the difficulty of keeping the nut from turning. Next the hexagonal part of the rod was rounded off and a ⅞-inch thread cut on it. This part was then screwed half way into a ⅞-inch nut, and the remodeled lock-nut was screwed into the other half of the ⅞-inch nut. It did not look pretty, but it kept the engine running until a new rod was secured—a matter of two months.

C. M. S.

Oakville, Wash.

"How Can He Increase the Draft?"

If my comprehension of Thos. W. Burdekin's sketch in June POWER, page 399, is correct, I believe that I can readily see what is the matter with his draft. As I understand it, the breeching or uptake leaves the top of the boiler at right angles, or nearly so, to the plane of the boiler, and then takes off at another right angle to the stack, with the 8-inch induced-draft pipe entering the breeching on the base of the angle.

The province of induced draft being that of creating a partial vacuum or difference of pressure in certain parts of the draft system, it follows that the movement of the air must be in the same direction, that is, away from the combustion chamber. In entering the 8-inch draft pipe near the elbow the induced draft has a tendency to set up a swirl of air against the inner corner of the elbow, due to the resistance of the column of air in the uptake and stack, thereby creating a back-pressure, counter to the natural draft through the fire-box and tubes, retarding the draft and reducing the amount of oxygen supplied to the fire.

Several methods of overcoming the difficulty present themselves, one of which is to continue the 8-inch blower pipe into the breeching until the end of pipe is past the corner of the elbow. This, however, reduces the internal area of the breeching to such an extent that the plan is open to some objection on that score.

A better plan would be to enter the 8-inch draft pipe near the point at which the breeching enters the stack, and at an angle of about 20 degrees. It will be noticed that this arrangement forces the induced draft directly into the stack, away from the combustion chamber, thereby creating a vacuum back of the point of entrance of the induced-draft pipe, causing an accelerated movement of air from the higher atmospheric pressure outside, through the ash-pit, up through the grates and fire-box, thence by natural course to the stack.

Another suggestion is to enter the 8-inch draft pipe directly into the stack, just above the point of entrance of the breeching or uptake, and put an ell on the draft pipe inside the stack.

Whatever method is followed to overcome the trouble, every effort should be directed toward forcing the induced draft away from the fire chamber and in an as nearly straight line as possible. The 30-inch blower, running at 2500 revolutions per minute, should furnish plenty of air for the purpose.

A. P. H. SAUL.

Buffalo, N. Y.

Judging from the letter from Thomas Burdekin, his trouble lies at the point of delivery of the forced draft. The air, after delivery from the blower pipe, has a tendency to spread, and, striking the inside corner of the uptake, forms an eddy current which tends to blow down upon the fire instead of forcing the draft.

If Mr. Burdekin will extend the blower pipe so that the delivery will take place a foot or so beyond the corner of the uptake, he may be sure of good results, the principle being the same as that of a steam jet in a siphon. A vacuum being formed behind the delivery nozzle, the outside air rushes in to fill the space. Discharging the air into the stack will give the same result, only the delivery must take place above the uptake opening.

BENNY.

Peoria, Ill.

Regarding Mr. Burdekin's letter in June POWER, I am of the opinion that he does not need any blower at all, but judging from the very plain drawing of the boiler setting and flue, he is utilizing a large per cent. of the stack energy to overcome the friction in the flue. This, at first glance, does not strike one forcibly, but it will be found that it is the case, and if he will do away with the right-angle bend where he says he put in the blower pipe, and incline the flue up as much as possible from the uptake at the front end of the boiler straight back to the stack, he will overcome, to a large extent, the difficulty of draft, assuming that the top of the stack is not surrounded in some way with buildings and other obstruction. He does not state the area of the flue but the drawing shows it to be square. A square flue will answer where you cannot get a round one, but the size of flue should be no less than the diameter of the stack, which is stated to be two feet. Whether the stack is of steel or brick, the article doesn't state. A two-foot stack 72 feet high is considerably too small for a boiler 6 feet in diameter and 18 feet long, but if he will overcome the friction in the flue, the stack might be found sufficient to do the work; but he will have to use every means possible not only to overcome this friction, but to make sure there are no air leaks around the doors or through cracks in the brick work, because the stack has got more than it should legitimately be called upon to do, without having to take care of extras, and the leakage around the front-tube doors and back cleaning-out doors is usually a source of robbery.

If, on account of conditions, he cannot give an incline to the flue, however slight, and the flue must of necessity enter the stack in the same vertical position that it now is, leaving the boiler to the right as the drawing indicates, then discard the present flue and form one out of a double easy curve from the present uptake in the boiler back to the flue opening in the stack. This will be the next best thing to having the flue run straight back over the boiler and enter the stack without any bend whatever.

If I interpret the drawing correctly, I mistrust that the first old boiler stood directly under the present flue opening in the stack, and he has simply utilized this opening for the new boiler which stands to one side, but the flue that he has now erected is about as bad as it could be.

The fact that he entered the blower pipe directly at the elbow, as the drawing shows, makes me smile. The only thing that a blower pipe, and especially of the size he speaks of, would do, would be to blanket the uptake in the boiler which, of course, he did not realize, otherwise he would never have placed it at this point.

OROSCO C. WOOLSON.

New York City.

"Why Would Not the Lubricator Work?"

On page 472 of the July number Arthur R. Mutton complains of difficulty of operation of his single-connection lubricator. Perhaps he can get the lubricator to supply oil continuously if he will lengthen the steam-supply pipe to the condenser at the top of the lubricator, so as to produce a greater pressure due to increased head of water above the condenser. I think the difference in velocity of flow in the engine steam pipe explains why the lubricator works in one case and not in the other.

CHAS. J. MASON.

Scranton, Penn.

"How Would You Correct the Crank-end Diagram?"

From the appearance of the indicator diagrams submitted with the letter bearing the above heading, in June POWER, it looks as if both ends need correcting. The head-end diagrams look as if they might have been taken from a slide-valve engine, showing cut-off at half stroke in both diagrams. The exhaust valve is slow in opening, and the steam valve is open too long.

As to the crank-end diagrams, the steam valve is too slow in opening, causing the loop on the compression curve. These conditions are shown in both diagrams.

The best way of correcting the valve setting depends entirely upon the make and type of engine. Usually in Corliss engines the adjustment for cut-off is made by adjusting the cut-off cams by means of the small reach-rod to the governor. The admission on the crank-end diagrams could be corrected by adjusting the steam-rod connecting the wrist-plate to the steam valve.

J. I. B.

Allentown, Penn.

"What Is the Matter with the Steam Line?"

I think the trouble illustrated in E. J.'s diagrams, on page 395 of the June number, is due to an incorrect length of either the eccentric-rod or the reach-rod which connects the wrist-plate and rocker-arm. It looks as though the wrist-plate does not vibrate equally on both sides of its central mark. Let E. J. adjust his rods so that both the rocker-arm and wrist-plate vibrate correctly, and I think his trouble will disappear.

CHAS. J. MASON.

Scranton, Penn.

In answer to E. J.'s question in the June number, I will say that the left-hand diagram (presumably the head end) shows a lateness of admission due to the radial rod from the wrist-plate being too long. The valve having too much lap, the unevenness of the steam line would be overcome to some extent by decreasing the lap on that valve; but he cannot eliminate that feature altogether, because that size and make of engine evidently has a double-ported valve, and at the beginning of the stroke, due to insufficiency of the steam supply, he is unable to obtain volume enough to bring the line up properly.

I have found a great many engines that give the same sort of diagram, and while in some cases it might be caused by the piston traveling over the indicator port, yet I think the first explanation the most probable. The diagrams show a good steam distribution, and the point of release is very fine. The sharp point at the beginning of the steam line on either end may be due to condensation in the indicator, or to the momentum of the pencil mechanism, which is more noticeable on a weak spring than on a stronger one. I recently took a diagram from another engine of the same make and was struck by the similarity.

ROVING HAL.

Cedar Rapids, Ia.

In reply to E. J.'s inquiry in the June number, I infer that the admission valves open too late, as the pre-admission lines of each end of the diagram lean toward the center of the card, and a sag, indicating a falling off of pressure, occurs in the steam lines at the beginning, which goes to show that the piston starts on its stroke before the admission valves have opened far enough to admit sufficient steam to keep the pressure up.

Increasing the lead on each end will, no doubt, give a much better looking card, as the remaining portions of the diagram are good. Of course, the lead should be increased the most on the end which shows the poorer steam line.

A. C. BROWNE.

Dannemora, N. Y.

In reply to E. J., whose query appears on page 395 of the June number, it is quite clear that insufficient lead is the cause of the trouble. There is nothing in his letter to indicate "which is which" of the diagrams. Therefore, I will have to say that the left-hand steam line being low at the beginning is probably due to insufficient lead. I can conceive no other cause. The right-hand one indicates a little more lead than is generally considered good practice, although the peak at the beginning of the steam line, due to the "fling" of the pencil motion, is a little disconcerting.

I believe that by increasing the lap at the right-hand admission valve and reducing the lap on the exhaust valves, then moving the eccentric forward until the left-hand card shows up nicely, the engine should work better. Release should take place early enough so that the release line will descend to a point down to the normal back-pressure line at the end of the stroke. In this way you get the full benefit of compression.

It seems not to be generally understood that the only really effective compression shown on a diagram is that which appears above the expansion line of the diagram from the opposite end of the cylinder. From the general appearance of these diagrams I conclude that the working parts of the indicator need attention.

WM. WESTERFIELD.

Charleston, Mo.

"A 100-Horse-power Steam Plant"

The articles in the July number under the above general title are first rate, and they furnish just the kind of information operating engineers often desire and require, which is not easily obtained in such compact form. I wish, however, to comment a little upon C. R. McGahey's article on page 428. While Mr. McGahey states that it is desirable to do without as many fittings as possible in the design and construction of such a plant, I think a few more could be added to the installation presented by him, without increasing the cost of the plant to an objectionable amount, when convenience and safeguarding are taken into account.

For instance, I think a separator should have been placed in the main steam pipe, instead of having to depend upon the drip-pipe shown in Fig. 1, page 428. (Mr. McGahey refers to a separator, thus showing that he knows it would be advantageous to have one.) A by-pass around the feed-water heater for both the exhaust-steam and the pump-discharge pipes would also make it possible to cut the heater entirely out of service, if for any reason it is required to do so, and at the same time not interrupt the operation of the plant.

A valve should be placed somewhere in the pump-discharge pipe to prevent the water backing up when the injector is in service and the pump is out of service. As it is, the pump-discharge valves seem to be the only means of checking the tendency to return flow. Suppose the engineer wishes to overhaul his pump-discharge valves with the injector running, then the valve suggested would be found useful. The pressure in the water-supply main may also be high enough to warrant placing a valve in the pump-suction line.

Finally, I would say that the introduction of a few unions in all the piping would make renewing, repairing, or further possible installation of machinery considerably easier and less expensive. Of course, there may be ways and means out of and through all possible difficulties, yet there are times when the need of a valve or union is urgent.

CHAS. J. MASON.

Scranton, Penn.

The Norton Gas Power Plant Report

I was much interested in the description in the July number of the gas-power plant of the Norton Company, telling something of the new Westinghouse gas engine. The consumption of the cylinder-oil is given as 3 gallons per week, which seems extremely low. I am inclined to believe that ten times this consumption would be nearer the value that could be reasonably expected with this type of engine. Excessive cylinder-oil consumption is one of the weak points of the double-acting tandem four-cycle engines. Three gallons consumed in an average run of 53 hours per week would correspond to 0.057 gallon per hour for the engine. Assuming that the engine runs at 100 revolutions per minute, and that about 20,000 drops of gas-engine cylinder-oil constitutes one gallon, it would use about 1/10 drop per stroke, according to the test report. This is divided between the two cylinders. It is rather difficult to see how such a small quantity of oil can be timed and injected as the piston passes the oil port.

It would also be interesting to see an indicator diagram from this engine. We have heard so much of the higher fuel economy of the high-powered four-cycle engine, as compared with that of the double-acting two-cycle, but the results obtained with this plant would certainly not indicate superiority. Evidently the engines are running with very low compression or otherwise the mechanical efficiency is quite low. Some addition of facts and figures as to these points would make the article more valuable.

LOUIS ILLMER, JR.

Cincinnati, Ohio.

"Use Hydraulic Check Valves"

In regard to J. W.'s inquiry on page 317 of May POWER, I will give my experience. I attached a steam-gage connection within 2 feet of the throttle of a Corliss engine running at 125 revolutions per minute. The steam pressure was 100 pounds. To avoid the effect of pulsation on the gage I placed a U, 18 inches deep, in the pipe, all below the horizontal run to the gage. In a union in one leg of the U was placed a brass disk containing a hole 1/32 inch in diameter. I supposed that as only water passed and repassed through the hole it could not do so quickly enough to affect the gage, but I found that the hole was too big, and when it was made small enough to keep the gage finger steady, it would clog too often. The hole was enlarged slightly, and the U was made 3 fet deep in the hope that more water would cause greater resistance and make up for the slightly larger hole; but it didn't.

I took out the disk and put a plug-cock just below the union, and with the engine running I closed it until the gage finger was almost steady. Now, in case the small opening becomes clogged, the cock is opened, and then brought back as before, but this has happened not more than twice in as many years. In this case 10 feet of pipe, as suggested by Mr. Crane in the June number, does no better than the original 4 feet in the run to the gage. It is all in the cock, the U being useful only as a pocket to insure that water only shall pass the cock. Nor has my experience with globe valves been satisfactory in such cases.

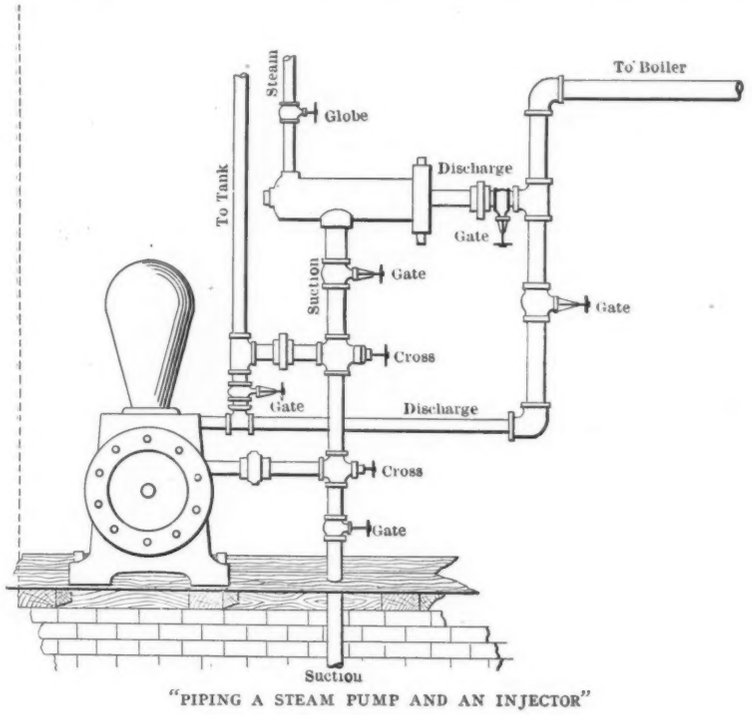
LLED.

New York City.

"Piping a Steam Pump and an Injector"

I read with interest the letters which have appeared from time to time regarding this topic. I think some of the plans submitted look better on paper than they would work out in practice. Looking at what "Injector" calls a simple plan, Fig. 2 on page 323 of the May number, I agree that it is "simple;" but let the flange packing blow from the water cylinder-head and it will be impossible to do business with the injector.

The cut herewith shows my plan, and while I do not think that it needs explanation, I would point out that either pump or injector can be repaired, leaving the other undisturbed, as far as its operation is concerned, and everything is conveniently located, too.



"PIPING A STEAM PUMP AND AN INJECTOR"

BEGINNER.

Exeter, N. .H

"Effect of Compression on Cut-off"

I have read with considerable interest Mr. Crane's letter relative to the effect of compression on cut-off, which appears on page 388 of the June number. Without wishing to "butt in," I would like to say, in relation to the matter of compression, that of necessity the point of cut-off will occur later if compression be increased, and the indicated horse-power of the engine remain the same. Compression means work done by the engine piston, instead of work done upon it, so to speak. The higher the compression the greater the exertion required to produce it, and if the delivered horse-power is to remain the same, the mean forward pressure must be increased to offset the increased work due to compression. Compression reduces diagram area, and as the terms of the $\frac{PLAN}{33{,}000}$ formula must be satisfied for a given result, later cut-off—which means greater diagram area—will occur. Then later cut-off means more steam consumed for a given amount of useful work performed, unless compression can be rightly called "useful work" and included in the total indicated horse-power. But I have found that the lower compression can be reduced (within reason, of course), the more economical the engine will prove.

There may be cases where a higher compression than that I should carry would perhaps be required. I have known engines to run quietly with what I call a high compression, and when the compression was considerably reduced they still ran quietly, but more economically. That seems to be a satisfying test for the cases in mind, even if it does not quite agree with the opinions and practice of some of my brethren in steam engineering.

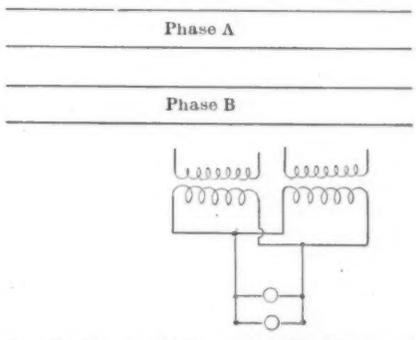
Every engine is surrounded by its own peculiar conditions, and is a "law unto itself," as we say, in the matter of compression as well as in other matters. So, what would be considered and perhaps proved to be high compression in one case might not at all be so for some other case.

CHAS. J. MASON.

Scranton, Penn.

Connecting Banked Transformers to a Two-phase Primary Circuit

Here is a mild problem in transformer primary connections. It is desired to connect two transformers in parallel at their secondary terminals and to supply the primary windings with current from a two-phase line. How are the primary connections made?



CONNECTING BANKED TRANSFORMERS TO A TWO-PHASE PRIMARY CIRCUIT

H. B. BRAND.

Brooklyn, N. Y.

Comments on July Contributions

On page 475 Frank Wood brings up the question of steam efficiency by having a "separate throttle for each cylinder of a duplex steam pump." For my part I can't see why it would have any effect on the steam efficiency. In ordinary practice the single throttle valve is opened just enough to make the pump run at the required number of strokes per minute. Now by having two valves, each side should be opened the same amount in order to have each side of the pump run smoothly, the valves being opened wide enough, of course, to give the necessary number of strokes. I believe that if there would be any saving of steam by having two separate throttles, pump builders would have equipped their pumps that way long ago, and as far as I know all duplex pumps have but one throttle. Let the pump builders give us their opinion.

The letter on the "Value of Indicator Diagrams," on page 475, was interesting and the examples cited are, no doubt, too true of small installations. In large power plants and steel mills, if anything seems wrong at any of the engines, the first thing done is to apply the indicator, and usually the trouble is located. Certainly it is not good practice to do everything else to locate the trouble, and then as a last resort put on the indicator. If in large plants the first thing to do is to apply the indicator, why should not the same rule apply to small installations?

Replying to W. H.'s letter on engine-room etiquette, on page 479, I believe that in an engine room the chief's word should be law. The assistant chief should obey the chief's command to the letter. If the assistant desires to indicate the engines with his own indicator during his watch, let him be man enough to ask permission of the chief.

Regarding Mr. Broden's remarks on "Boiler and Engine-room Ventilation," on page 475, I would say that engines are often placed in the corner of a building near the walls, just enough room being left for the engineer to squeeze through. In some cases it becomes necessary to do this, on account of small floor space, but whenever space allows there should be given enough room. Not only is it more pleasant for the engineer, but it gives elbow-room in case of a break-down.

At present boiler- and engine-room ventilation is given considerable thought in new lay-outs, but the condenser seems to be forgotten frequently. It is usually put down in a pit, with barely enough room to squeeze around it; and when the piston and rod must come out, connections must be broken, and the condenser hoisted out of its pit. Condenser pits are usually sweat boxes, but in some recent lay-outs motor-driven exhaust fans take the warm air away and afford some ventilation.

In reply to W. F. Burrow's inquiry on page 469, as to cleaning oily exhaust, I believe a good oil separator put in on the exhaust-steam line between the engine and the heater, will take out most of the oil before the steam is condensed. Oil separators do not eliminate all of the oil, but are supposed to have an efficiency of more than 90 per cent.

J. I. B.

Allentown, Penn.

Regarding Arthur R. Mutton's letter on this subject, on page 472 of the July number, in my judgment the reason why his lubricator did not work is that it was too close to the steam pipe, the temperature being too high to permit sufficient condensation.

My idea as to the cause of the condensing chamber being full of oil is that all the water must have been blown out of it during the process of filling. I suppose that after filling it was too hot to condense the steam.

In answer to H. H. H.'s inquiry, on page 479 of the July number, as to whether it is right for an engineer to take indicator cards with his own indicator without the consent of his chief, my notion is that an assistant who has a proper regard for his chief will always get his chief's consent in matters of this kind, although it may not be wrong not to do so. Anyway, I think this much is due to the man who by hard and unremitting toil, with both head and hand, has attained the position of chief engineer.

Referring to J. O. Benefiel's communication on page 480 of the July number, in my humble opinion his method of connecting blow-off pipes is ideal. The only disadvantage I see is that it would be difficult to renew it, if need be.

Feeding a boiler through the blow-off is not a bad plan, still I think feed-water should enter the boiler at the highest temperature it can be heated by the exhaust, and it should enter the boiler at the coolest place. By this means strains due to unequal expansion would be lessened.

W. F. Burrow.

Hico, Tex.

The 100-horse-power plant described by Mr. Hobart, in the July number, shows good practice, and I was favorably impressed by his plans to keep out of the expense account a lot of "pet schemes" for using up the surplus fittings. I believe, however, that with the pumps piped with by-passes, as shown, it would be in order also to by-pass the exhaust from the main engine around the heater. I have always found a safety-valve on the motor connection of a closed heater desirable, although not absolutely necessary.

Mr. Taylor seems to have handled "A Question in Belt Operation" in a very convincing manner, and shows why the belt will run off the so-called low side of the pulley. However, I believe that the theory as regards the belt running to the high side of the pulley is correct, but this has a condition attached to it, namely, the shafts of the pulleys must be parallel to the same plane, otherwise the rule will not hold good.

The only advantage of having two throttles on a duplex pump, as suggested by Mr. Wood, on page 475, would be to make both sides of the pump run at the same speed, regardless of how tight or loose the packing may be. I have sometimes wished I had such an arrangement, but something worse usually happened about that time, and I forgot all about it until I packed the pump again.

I do not believe W. H. will gain anything by changing his condensers, as per the sketch shown on page 476, as it is evident that his low vacuum is caused from the fact that the water in the condenser vaporizes and fills the air pump with steam, due to a high hot-well temperature and absence of pressure in the vacuum side of the condenser. It is very evident that if the circulating water is 100 degrees Fahrenheit, the temperature of the condensed steam must be rather high and the "wet-and-dry" system will not lower the temperature of the condenser any. If one had an air pump that would displace as much vapor per minute as the low-pressure piston, he would get a good vacuum, but it would take the same horse-power to run the pump as the engine would develop.

I suggest using a jet of cold water during the hot season, injecting it into the exhaust pipe just before it enters the condenser. A 1½-inch pipe has helped to maintain a good vacuum on a good many 1500-horse-power condensers, to my knowledge.

In regard to the question of H. H. H., on page 479, about taking indicator cards without asking the chief's consent, I would advise him to first ask the chief about it, for there are liable to be all kinds of "stresses" set up, so to speak, if he does not. In the first place, if the chief is the right kind of a fellow, he will readily give his consent; in the second place, if he is not, he will probably make a noise like a time-check when he finds it out.

I am willing to lay myself liable to all kinds of censure and state that I agree with Mr. Benefiel in all that he says about "Feed and Blow-off Pipes," on page 480, for down in the southwest Missouri district this used to be the rule rather than the exception, the only difference being that we did not take the trouble to cover our pipe with brick. We pumped our "half and half" (so called from being about one-half water and one-half alkali) through the blow-off and never had any trouble. We were not always lucky enough, however, to get a long-sweep elbow.

Ed. H. Lane.

Kansas City, Mo.

"Unwarranted Discrimination"

I was pleased with the manner in which you deal with the above subject in the editorial columns of the July POWER. For the life of me, I cannot see wherein the difference lies, so far as a man's value as an engineer is concerned, whether he gets his knowlege of the essentials of engineering in a technical institution, or by burning "midnight oil" and delving into the grease and grime, thus combining knowledge and practice in the very best manner. I think, everything considered, that the latter when his skill and knowledge equal that of "the other fellow" is entitled to the greater consideration, because as I once heard a great preacher say: "It is not what a man accomplishes that is creditable, but the conditions and environments under which he accomplishes it."

There was never a more patent truth uttered than the above. The man who strives against the obstacles that poverty places in his way, and by dint of perseverance wins, deserves greater credit than the fellow who attends a technical school and gets instruction paid for perhaps by money he never earned a cent of. It is poor encouragement to ambitious men who run the up-hill race, who have to fight the battle of life against great odds at the best, to find themselves discriminated against instead of encouraged. The man who has won by hard work and perseverance by his own unaided efforts, is now and always has been the ideal man in the eyes of the best of the human race, and in turning away from the good precedents of the past and present, the Honorable Messrs. Black and Cortelyou have certainly added nothing to the admiration of the great American public for themselves.

To those who are watching, it has long been apparent that in certain quarters an effort is being made to favor the favored. It would seem that politics is the game that is to be played at the expense of the public service, as well as the public cash. To become a good operating engineer requires experience as well as study, and if the man who has studied, but has not well immersed himself in practice, gets a position where it is imperative that an experienced practical man be retained, the only possible arrangement is the one that is now, even, only too well known; that is, to have the technical man with a "knowledge box" full of hazy ideas drawing the salary and getting the honor, while some better man is doing all the work and getting no credit.

As to the practical man who has taken a course of instruction in a technical school, either resident or correspondence, in order to better equip himself for his work, I have nothing but words of praise to offer. But this sort of fellow will get there without having any discrimination made in his favor against anyone whatsoever, and any self-reliant, self-respecting man would be ashamed to ask for such discrimination, and would be equally averse to profiting by it.

WM. WESTERFIELD.

Charleston, Mo.

"Incorrect Indication of Water Level in Boilers"

Calvin B. Ross's article on "Incorrect Indication of Water Level in Boilers," on page 469 of the July number, reminds me of an incident where a peculiar cause rendered a gage glass unreliable and might have caused serious trouble. It was in a large grease-extracting plant where the grease is extracted by naphtha from scrap-leather, the naphtha distilled off and the grease thus recovered. The condensers emptied into a tall receiving tank, and as 18,000 to 20,000 gallons of naphtha are in use all the time it was very necessary to know when this tank had become almost full, otherwise the naphtha would soon start flowing through the vent lines, and if much liquid escaped there it might possibly bridge over to the boiler-room fire, flash back and cause 20,000 gallons of trouble.

A new de-greasing tank had been started up and we were forcing the stills and condensers to handle the extra liquid; the receiving-tank gage showed nearly full when the engineer happened to open a pet-cock on the vent line and was almost paralyzed to see liquid naphtha run out. He quickly blew out the gage, both top and bottom, and found all clear, the liquid rising up to the original mark again and showing about 12 inches from the top or about 9 inches to the vent pipe—still the pet-cock on the vent line showed naphtha. The engineer did not understand this paradox, but he decided to run no chances, so he pumped the tank empty.

Investigation afterward disclosed the trouble: the stilling having been forced, the extra rush of vapor had carried some grease along with it, this had gone through the condensing coils and fallen into the naphtha in the receiving tank, where it settled down to the bottom, forming an almost saturated solution with the naphtha; as this was heavier than the pure naphtha, it therefore took a greater hight of naphtha inside to balance the smaller column in the gage glass. A recurrence of this has been prevented by replacing the long column by four separate gage glasses.

GEO. P. PEARCE.

Pennsylvania.

Cross-belt Troubles

In answer to L. L. Arnold's inquiry on page 117 of the February number, as to the best way to remedy his cross-belt trouble, I think that the idea shown in Fig. 1 will be efficacious. It will be noted that the secondary pulley on the slack side of the belt is placed so as to increase the belt contact on the driven pulley, and the other is more nearly in line with the other side of the driven pulley, so as to lessen the friction on the taut side of the belt. Lately I had a cross-belt to contend with which acts just like Mr. Arnold's, and this is the plan I propose to adopt to overcome the trouble, although for the time being I have placed a block of wood against the edge of the slack side of the belt, near the small pulley, as shown in Fig. 2. This rig is in an out-of-the-way place, and although I consider it as unscientific as can be, it keeps the belt on all right. It is rather hard on the block, but blocks are easily obtained. I will not say what it does to the belt, beyond stating that it does not enhance its longevity.

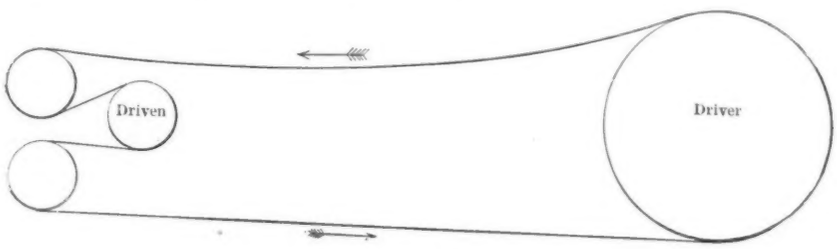


FIG. 1

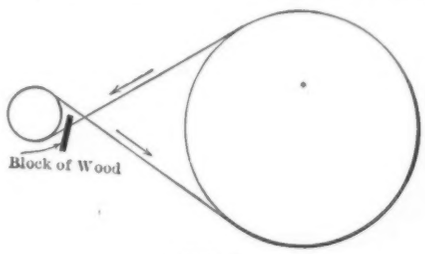


FIG. 2

D. T. BEDFORD.

Brantford, Ont.

The Lehigh class of 1887, at the twentieth reunion, held on Monday evening, June 10, decided to give to the university a power and heating plant. Members of the class will furnish the apparatus.

POWER

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Water in Superheated Steam

One of the first things that the student of steam engineering learns is that superheated steam cannot exist in the presence of water. The steam being above the temperature at which the water will boil gives up its superheat to the water and evaporates it until the condition of saturation is reached.

It is equally true that ice cannot exist in an atmosphere above 32 degrees. The atmosphere being above the melting point of the ice gives up its heat to the unstable solid and it melts.

And yet there is the ice man.

Both of the above statements are true in the abstract, in the long run. Leave the ice in the sun long enough and it will melt; leave the superheated steam and the water together long enough and the steam will lose its superheat. But this heat transfer is not instantaneous. It takes time, and a good deal of time, to effect the process, so that when experimenters have undertaken to produce steam of a given degree of superheat by tempering steam which had been superheated above the desired point by spraying water into it, they have been surprised by being able to draw water from the bottom of the pipe and superheated steam from the top. It is this difficulty of getting a sample of steam uniformly superheated to a given temperature which has been the main factor in producing the discrepancies and incongruities in the results and conclusions of the numerous experimenters who are engaged in determining the specific heat of this elusive fluid.

The Substitution Evil

Recent developments suggest the advisability of reprinting the following editorial which appeared in POWER for September, 1891:

The evil of substitution has been very forcibly brought to the attention of the reading public, through a paper presented by Frank A. Richardson to the National Editorial Association, at their convention at St. Paul. The practice complained of is not confined to retail druggists and grocers, but we are sorry to admit is indulged in by the dispenser of engineering supplies as well. An engineer, or steam user, goes to his supply man for an order of "Vacuum Oil," "Lord's Boiler Compound," "A Penberthy Injector," or any of the one thousand articles in the line of supplies and appliances, which have become well and favorably known, and which has in some way impressed itself so favorably upon his attention that he has concluded to purchase it. He is informed by the not over-scrupulous dealer that the supply of the desired article has unfortunately run out, but that he can give him another article "of my own make," or "put up especially for me," or "which is rapidly taking the place of so-and-so," for less money, and if the customer has not the self-assertiveness to insist upon having what he wants, and asks for, he procures, usually, an inferior article; and the smart salesman makes about twice the profit he would from the sale of the standard article first requested.

This practice is nothing less than downright robbery, and should receive the condemnation of every fair-minded person. Not only is a fraud perpetrated upon the man who buys the goods, but the manufacturer of the article first called for loses the benefit of the sale; and in many cases, it is only after his ingenuity, application, mechanical skill and capital have created the market, and the demand for the article, and the uniformly high character of the originators' own goods or appliances has established a confidence in them, that the imitator begins to avail himself of the other man's labor and money. When a dealer tells you that he has something "just as good" as something else, it is a pretty good recommendation for the "something else" that he chooses it as a standard of comparison, and the purchaser will usually make no mistake in insisting upon being supplied with the original article. The dealer will usually find that he can get it for you, and in many cases with astonishingly little trouble, when he finds that you know what you want and are bound to have it.

The End of the Ash-burning Fiasco

There is a tragedy behind the following items. A month or two ago everybody was speculating upon the possibility of burning ashes. It was no trouble at all to find men of apparently good sense, ordinarily, who were willing to affirm that they had done or were doing it at a profit, and thousands who ought to have known better were disposed to regard their experiments seriously. Notwithstanding the alleged profit of anywhere from ten to forty per cent. so easy of realization, we doubt if a consistent ash-burner could be found today, except it be one who saves his "cinders," as every frugal housewife has always done.

(Copy)

May 16, 1907.

Dr. H. K. Hoy,
1425 Twelfth avenue,
Altoona, Penn.

Dear Sir:

Yours of the 14th is received, and we have sent you under separate cover two copies of the June number containing the discussion of the Elmore process.

You appear to be dealing with the matter in good faith, and on this assumption we advise you most earnestly not to sink

any more money in the thing until you have an actual engineering test made under the supervision of competent engineers. Haphazard trials, such as those you have mentioned, signify nothing whatever. Have a ten-hour test run under the control of a competent engineer and you will get some actual information as to the value of the process, which will more than pay you for the expense of having the test made. If the process were of any value, engineers would be the first to welcome it. There would be no opposition whatever; and if you are handling the matter in good faith, you should be the first one to recognize this fact.

Yours very truly,
POWER,
Cecil P. Poole, Editor.

ASH-BURNER DISCOVERER'S BACKER A SUICIDE

Altoona, Penn., July 5.—Dr. H. K. Hoy, 58 years old, a homeopathic physician, who financed cobbler John Elmore's ash-burning discovery, and lost considerable money when it failed to prove a money-maker, committed suicide this morning by drinking a mixture of carbolic acid and laudanum. Worry over his financial losses in the Elmore discovery is said to have caused him to take his life.

Effect of Gas-engine Combustion Products on the Ignition of a Fresh Charge

At a recent meeting of one of the English engineering societies, one speaker made the somewhat rash statement that retaining part of the products of combustion in a gas-engine cylinder improved the combustion of the next charge of fresh mixture. As it was stated, the proposition is an absurd one. It is quite possible that, in engines which are jacketed all over, and which are very effectively cooled, retaining some of the hot spent gases will improve the combustion of the fresh charge by carrying its temperature above that which would be produced by compression alone. But to say that a proper mixture of gas and air will burn better when diluted with inert gases is utter nonsense. In order to support his contention, the speaker stated that he had noticed that when a hit-and-miss engine misses one explosion the next one is weaker than those occurring regularly. It depends entirely on the method of "missing" whether the charge after a missed explosion would be more or less dilute than ordinarily; also, as to how much the idle stroke would cool down the cylinder. If the engine was fitted with an automatic inlet valve, and the explosion was missed by holding the exhaust valve open, the piston merely sucked in and forced out hot exhaust gases, and the fresh charge taken in after the governor released the exhaust valve was mixed with the same quantity of inert gas as usual. As a matter of fact, our observation has been universally that a hit-and-miss engine which skips explosions by cutting off the fuel supply invariably gives an abnormally vigorous explosion when it resumes firing.

Living Conditions in the Engine Room

Does it ever occur to you as you walk over a grating in the sidewalk and get a blast of hot air that almost takes your breath away, that there are men working down in the cellar that the hot air comes from?

Do you, who swelter and fume when the thermometer gets to ninety degrees, realize the disheartening depression which goes with a continuous exposure to one hundred degrees and over?

If it were your lot to be obliged to look after that plant, would you pass your time in among the thickly placed and unprotected cylinders and pipes, keeping everything up to its best efficiency, forestalling accidents and interruptions, making the best possible use of the coal, and trying to make a record for yourself and a dollar for your employer?

Or would you get the thing to running in the briefest possible time, and getting out as quickly as possible, stay out as long as possible in such of "God's pure air" as percolates into the back alley which gives access to the plant?

Do you ever think, when a greasy, sweaty, begrimed and unwashed individual sits down beside you in the street car, that that man would prefer to be clean; that he realizes his unsavory condition; that he feels the edging away of those with whom he comes in contact, but that his work is such that he can but get dirty; and the facilities given him are not such that he can get clean?

The running of a steam plant is necessarily dirty and uncomfortable work. One cannot shovel coal and wipe up greasy bearings and clean out scaly boilers and remain immaculate. Boilers and piping and cylinders will radiate heat, and in the submerged and out-of-the-way corners, into which the steam plant is ordinarily tucked, this heat is hard to get rid of.

But there are plants, city plants, which are comparatively decent; where radiating surfaces are covered, even if the covering costs more than the coal which it will save; where the men have facilities for changing from a presentable street costume to a working suit, and a place to put their clean clothes where they will not share in the general grime before the knocking-off hour; where the men are encouraged by bathing facilities to refresh and make themselves presentable and agreeable before they emerge to mix with their fellow men, and where a little expenditure for fans and other means of ventilation, which will make the place more endurable during working hours, is not withheld nor begrudged.

And aside from its humanitarian side, such expenditure is sound economically, in that it secures better service and the choice of better help, for men will naturally seek such surroundings.

Sitting on China Eggs

It is pathetic to see a manufacturing establishment and its entire force working conscientiously along obsolete lines, and this is just what a considerable number of gas-engine builders are doing. In some factories mediocre engines are turned out by out-of-date shop equipment from designs which progressive engineers have abandoned, all in the firm belief that the plant is doing fine work and that the steady decrease in orders is due to some mysterious commercial conditions peculiar to the gas-engine industry. It is deplorable. Not only are such plants doomed to disaster unless the management wakes up, but their product, as long as they last, reacts on the industry as a whole. With the fine future that awaits any well-designed line of gas engines, it is a great pity that builders of the class under discussion cannot be brought to see the futility of their present policy. The fact is, however, that the merest hint of the real status of their work either engenders acute indignation or incites compassionate scorn.

A Gas-turbine Suggestion

The chief obstacle in the development of a practical gas turbine is the high temperature at which the burning gases must enter the turbine in order to avoid a prohibitive sacrifice in economy. Thus far no material has been produced in which are combined sufficient mechanical strength for vanes and the ability to withstand the requisite high initial temperature of the working medium. The successful combination of the steam turbine and the reciprocating steam engine appears to point out the way to at least a tentative solution of the gas-turbine problem: Burn the gases first in the cylinder of a reciprocating engine and deliver the exhaust gases of that engine to a turbine. Without sacrificing any of the engine's output the gases would go to the turbine at sufficiently high temperature and pressure to give a fair working range without exceeding the heat-resisting ability of the turbine vanes. A gas turbine cannot be operated "condensing," of course, but a temperature range of something like 700 to 800 degrees Fahrenheit would be obtainable with the arrangement suggested.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

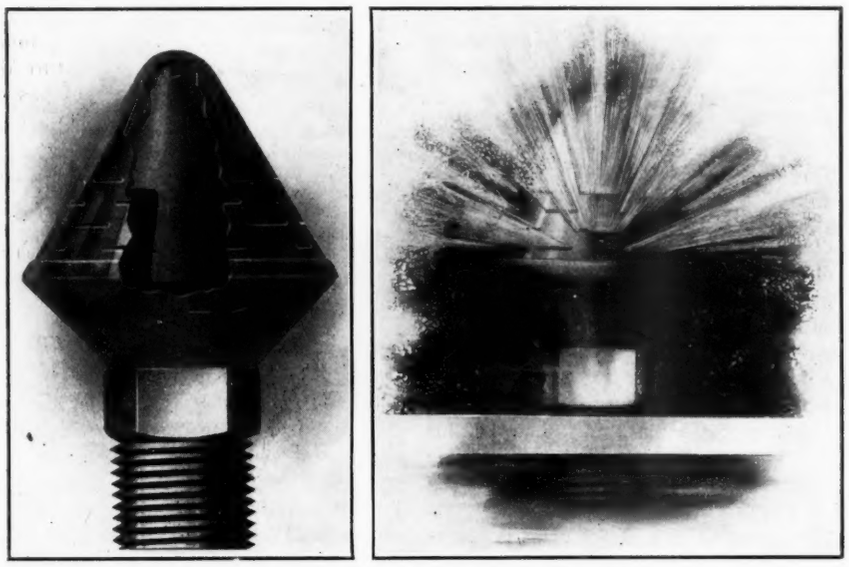
MUST BE NEW OR INTERESTING

The Scaife Strainer for Mechanical Filters

Mechanical filters are distinguished from the sanitary or slow sand filters, first, by the use of a gelatinous blanket formed by the action of the coagulant on the filter bed; second, by the method of washing the filters; and third, by the higher rate of flow through the filter bed.

In order to have an efficient mechanical filter it is absolutely essential that proper provision be made for washing it, which means breaking up the sand bed to carry off the collected mud, silt and bacteria.

There are many devices on the market for breaking up a filter bed to enable the wash water to carry off the mud, etc.; first, mechanical rakes which agitate the sand bed during the washing process, that is, when the flow of water through the filter is reversed; second, air agitation combined with the water, or air introduced separately as may be desired; third, strainers.



THE SCAIFE STRAINER FOR MECHANICAL FILTERS

In most cases no other method than the pressure of the water from the strainer need be used in the washing process, and it is all that is necessary under ordinary conditions if the strainers are properly designed and distributed.

Of the many strainers that have been put on the market, the greater number have been circular disks of perforated metal, the perforations being either round or narrow rectangular slots. In the ordinary operation of the filter this type of strainer gives satisfactory results, that is, it prevents the sand from passing out with the filtered water; but when it becomes necessary to reverse the flow of water to wash the sand bed, a very great quantity of water is required and little or no velocity is obtained, due to the size and number of the openings in the strainer, the area of the openings being in many cases larger than the area of the supply line which carries the water for washing the filter. The small perforations in the strainers cause a great deal of friction, and the area of these perforations must be very much in excess of the actual area of the pipe outlet from the filter, in some cases as much as four or five times as great. This being the case, an enormous quantity of water must be introduced to get an appreciable velocity, and even then it is difficult to get a jet sufficient from each strainer to give a thorough washing.

The strainer here illustrated consists of an inner and outer cone, the inner cone being movable and of such shape that the openings in the outer cone are partially closed off when washing. The number of openings which are closed off can be adjusted in each particular case, so that the area discharging water into the filter bed can be accurately adjusted to the size of the wash-out pipe.

The inner cone is held in place when washing by the pressure of the wash water, as the stream entering the strainer strikes the closed portion of this cone, thus holding it firmly in place. Thus the strainer has an ample area to deliver the filtered water, but when washing the inner cone reduces the area of the slots in the outer cone so that the combined area of all the strainers is a little less than the area of the pipe through which the wash water is introduced.

In this way a uniform pressure can be maintained in each individual strainer, to give a high velocity of the wash water through the openings of the strainer, which are arranged to give a radial discharge, thus insuring a thorough washing of every part of the sand bed.

The efficiency of these strainers has been thoroughly demonstrated by very exhaustive tests, and they are used in the water filters, also in the filters used with the Scaife and We-fu-go water softening and purifying systems manufactured by Wm. B. Scaife & Sons Company, of Pittsburg, Penn., with most excellent results.

The Ferguson Sectional Superheater

One of the latest superheaters of the small-tube type to be patented in this country is the Ferguson, and it has many points in its design which commend it for special mention among the members of this type of apparatus. It is suitable for giving high or low degrees of superheat and is easily adapted to all classes of boiler, especially to those of the shell or return-tubular pattern. Lack of accessibility has been a very frequent failing in superheaters, and the Ferguson apparatus has been designed with the object of improving upon this too common fault, being so constructed that every joint can be examined with the boiler in service and any part can be removed for repair without disturbance or disconnection of the remainder of the superheater, which can remain at work without the missing portion. This is effected by the adoption of independent sections, a form of construction, moreover, which presents the further advantage that the sections may all be of very moderate weight and the overhead tackle for use in removing parts may be of an equivalent lightness. According to the number of sections installed in any particular instance, so will be the general degree of superheat obtained. From the

position of the headers it will be plain that when removing or adding sections or otherwise dealing with them, the steam-pipe connections do not require to be disturbed.

But a point on which the designers perhaps lay more particular stress is the manner in which the pipes are taken from the headers. They all rise from the top of the headers, thus obviating the danger of getting water into the superheater pipes, and affording the opportunity readily to drain it out from the headers.

The feature is likely to be a considerable safeguard against priming troubles and the choking of the small tubes with scale matter carried forward with the priming. This method of leading off the tubes possesses the incidental advantage that no joints remain in the hot gases, and this, in a small-tube superheater, is a point of some considerable importance and tends to longevity of the tube joints.

The tubes and headers, indeed the whole apparatus, is of mild steel throughout. Fig. 1 gives details of the header with the tubes in position, and a series of tubes is also shown separately.

The headers are so arranged that one end of each is connected to the steam inlet and outlet branches respectively, and as many sections as may be desirable can be fitted, their flanges being bolted to the headers. Each flange or pair of flanges takes three looped tubes, and, when removed for repair or to reduce the superheater surface blank flanges cover the gaps left by the removed sections, these flanges, like the section flanges, being bolted to the headers. Similarly, in any emergency a section can be quickly replaced by a new one with a minimum of delay and stoppage.

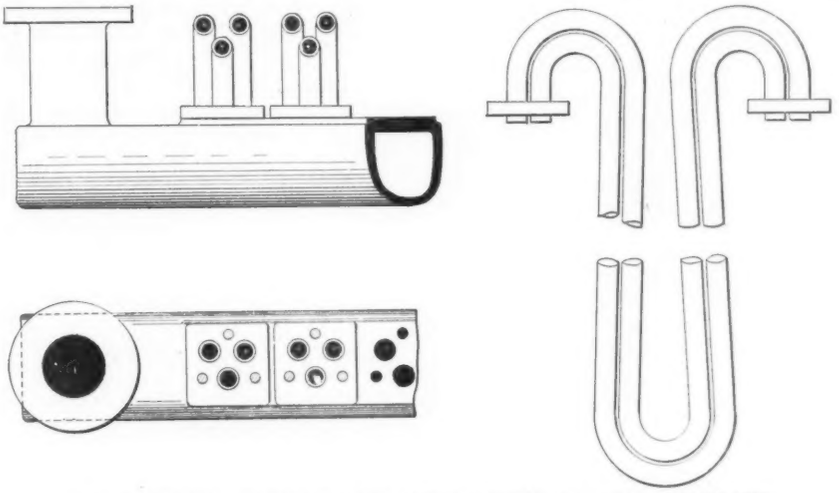


FIG. 1. DETAILS OF THE HEADER AND A SECTION OF THE SUPERHEATER

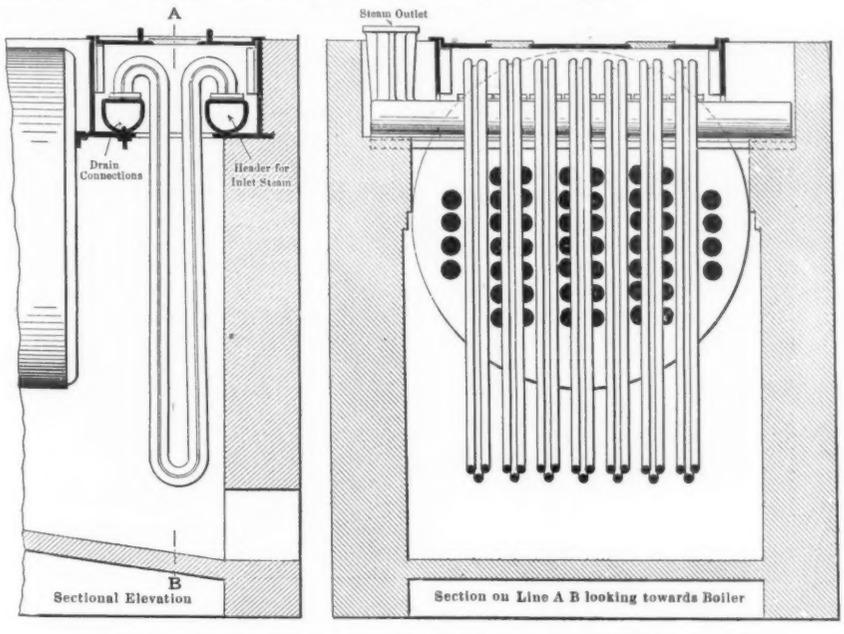


FIG. 2. APPLICATION OF SUPERHEATER TO A RETURN-TUBULAR BOILER

The application of the superheater to a return-tube boiler is shown in Fig. 2.

A. Venning, of 214 Havemeyer building, New York, is introducing the apparatus in this country and has arranged for its manufacture by W. K. Mitchell & Co., Ellsworth street, Philadelphia.

Smooth-On

Smooth-On is a chemical-iron compound first made in 1893 by Vreeland Tompkins, graduate of Rutgers College, who sought to form a "chemical iron" that could be applied to cracks and holes in iron to make permanent repairs. It was recognized that such a compound must metallize practically as hard as iron, and expand while metallizing so as to completely fill any opening into which it is introduced, and force itself into the grain of the iron. Also, when metallized, it must expand and contract the same as iron. After two years' experimentation this was accomplished and the compound, which was named "Smooth-On," forms the base of the different Smooth-On iron cements made by the Smooth-On Manufacturing Company, of Jersey City, N. J.

Smooth-On iron cement was first prepared in powder form only. To use it, water was mixed with it until it attained the consistency of stiff putty. The mixture was applied to cold metal immediately, as it metallized rapidly, in a few hours becoming as hard as iron, of the same color, and with a like power of expansion and contraction. This cement, while very useful where small quantities were required, necessitated an undesirable hurrying of the work when handling large quantities. By further experiment a solvent was found which would evaporate upon the application of heat, and this enabled Smooth-On to be prepared and kept in paste or fluid form until wanted for use. The fluid preparation of Smooth-On greatly enlarged its scope, as in this form it may be applied to either hot or cold metal.

There are now six Smooth-On preparations, each made for a special purpose. "Smooth-On for foundrymen," the first Smooth-On iron cement made, is for removing blemishes from iron or steel castings. "Smooth-On for engineers" is for making repairs on steam or hydraulic work, when the application can be made to cold metal. One example will show the value of this cement. Seven years ago the 7,000,000-gallon centrifugal pump at the New York Navy Yard split almost in two, due to a sudden strain. The crack was 20 feet long, and it was ascertained from the makers of the pump that it would take 26 weeks to produce duplicate castings to replace the broken parts. It was suggested by the engineer-in-charge, who had used Smooth-On, that he could repair the pump with this cement, and permission was given. It was repaired successfully in three days.

The third Smooth-On iron cement placed upon the market is called "Smooth-On Joints," for making hub-joints in cast-iron pipes. This cement was used on the hub-joints at the New York State buildings, at Poughkeepsie, N. Y. "Smooth-On Elastic Cement," the fourth

Smooth-On product, is prepared in paste or fluid form, and is kept in air-tight cans until it is wanted for use. This fluid cement, which is often called "magic iron," will run into very small cracks, holes or seams, filling them with iron. A can of this cement may be purchased in nearly every seaport in the world, as it is universally used by steamship engineers.

The fifth Smooth-On specialty, "Smooth-On Iron Cement Sheet Packing," is a combination of Smooth-On iron cement No. 1 and rubber. In packing, the Smooth-On has the same action as when in the powder form, namely, expanding slightly when it comes in contact with steam, hot or cold water. This permits it to completely fill any uneven places in the flanged faces, making a perfect joint instantly. This packing is used in the engine room of the Brooklyn bridge.

The sixth Smooth-On specialty is the "Smooth-On Coated Corrugated Steel Gasket." It is made from specially prepared mild, tough steel, stamped with concentric corrugations, and then coated with Smooth-On elastic iron cement. For flanged joints, these gaskets are designed to withstand any pressure or temperature that the pipe will stand, and are not affected by steam, water, oil, air or ammonia. It is stated that they are being successfully used under 3000 pounds pressure in hydraulic mining.

The Brooks Centrifugal Pump

It is said that the inventor of this pump got his idea by rapidly rotating a pipe with a T screwed to one end of it while the other end was immersed in water. The centrifugal force given to the water in the T expelled it violently and it drew more after it, maintaining a continuous stream. It remained only to fashion the revolving head or piston and the casing containing it so that the water would be received, accelerated and delivered without shock and eddy, to produce a simple and efficient form of pump.

The arrangement adopted is shown in the accompanying engravings. The center of the entering column of water will, it is argued, take the centrifugal motion slowly at first, following the dotted line *a*, Fig. 1, the water at the edge of the column will enter at once into a zone of rapid motion and follow the line *b*, both dotted lines being resultants of the inward velocity due to the complement of the suction head and of the velocity at right angles thereto due to the centrifugal force. The delivery edge *c* of the piston is made of a width to accommodate the flow at the resulting velocity. A lip overhangs each of the two outlets of the piston, as shown in Fig. 2. These lips are directed tangentially and rearwardly and serve as guards or division plates to keep the outflowing columns of liquids from impinging directly against the annular body of liquid between the casing and piston, minimizing eddying, and to some extent to impel the liquid toward the casing outlet. Throughout nearly the entire circumference of the annular space between casing and piston the liquid is flowing in the same direction with the piston movement. The lips aid this flow and confine the disturbance due to the outflow to the space immediately surrounding the piston.

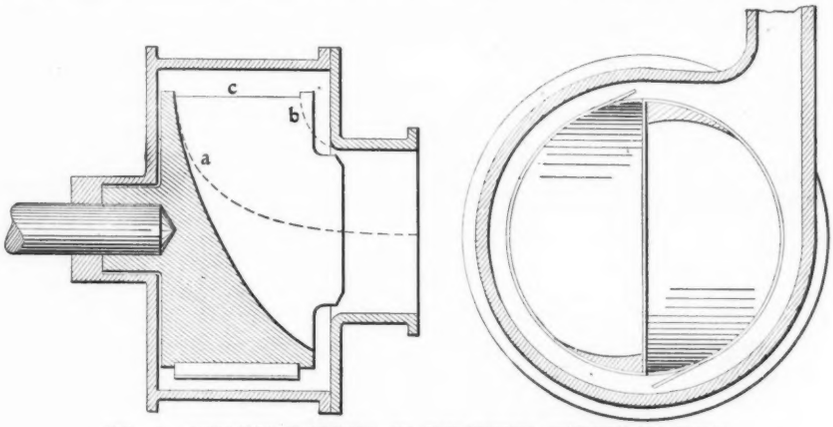


FIG. 1. SHOWING PRINCIPLE OF THE BROOKS CENTRIFUGAL PUMP

The Dayton Hydraulic Machinery Company, Dayton, O., is the manufacturer.

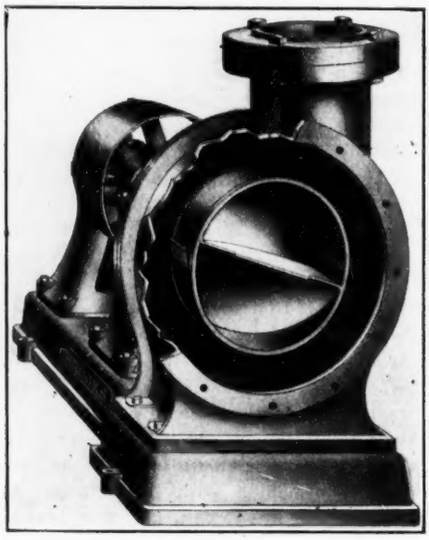
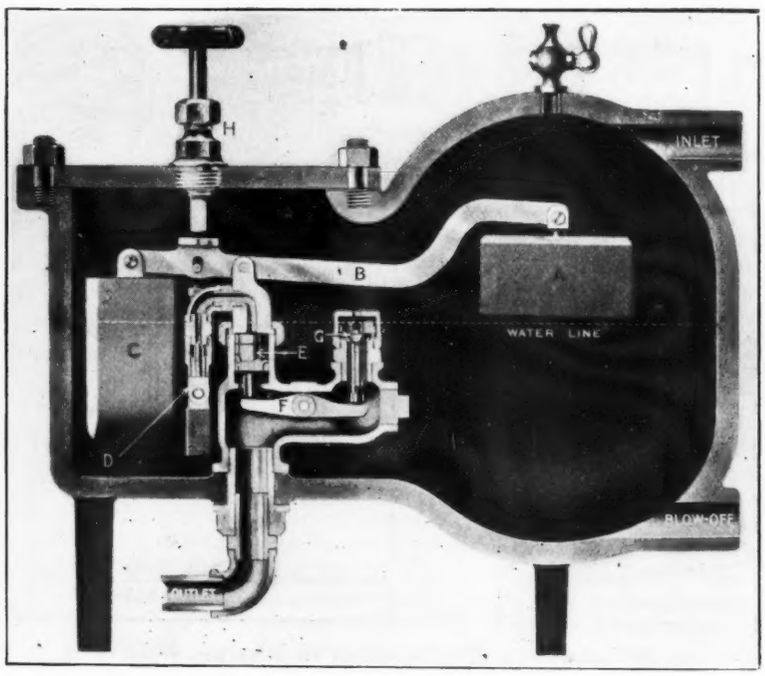


FIG. 2. SECTIONAL VIEW OF THE BROOKS CENTRIFUGAL PUMP

The "Sterling" Steam Trap

Herewith is a sectional view of the "Sterling" steam trap. It is positive and automatic, with a quick discharge and large draining capacity. The actuating valve is controlled by gravity, and the valves and seats are of United States Government metal, and renewable; in fact, all parts



THE STERLING QUICK-OPENING TRAP

are interchangeable. It is noticeable that there is an absence of packing, joints, hollow floats, diaphragms, buckets and springs.

The operation is as follows: When the condensation rises in the casing the soapstone *A* acts as a float and raises the lever *B*, by the aid of gravity weight *C*, until the top of the lever slot engages on the pin in the slot, thereby opening the pilot valve *D*. This admits pressure on the piston *E*, which operates the rocking lever *F*, opening the large discharge valve *G* and allowing full discharge through the same size outlet as inlet.

As the water discharges, the soapstone and lever follow the water, picking up the pilot valve, thereby cutting off the pressure from the piston and allowing the casing pressure to close the discharge valve.

While if desired a gage glass may be installed to indicate the conditions within the trap, the actual working condition is readily ascertained by means of the "trivalve" *H* on top of the casing. These traps are built in two weights: one, called the "Sterling Junior," is for pressures up to 125 pounds; the other, "Sterling Senior," for pressures up to 225 pounds. The manufacturer is the Templeton Manufacturing Company, 22 Randolph street, Boston, Mass.

The Woolley Smokeless Furnace

The Woolley furnace is designed to burn bituminous coal without the production of smoke. In it the gases driven off in the distillation of the coal are intended to be consumed in a large, hot fire-brick chamber, to permit the combustion process begun in the fire-box to continue uninterruptedly until complete, before coming in contact with the cooler surfaces of the boiler. The gases entering this fire-brick chamber from the fuel bed carry with them a sufficient quantity of air, as

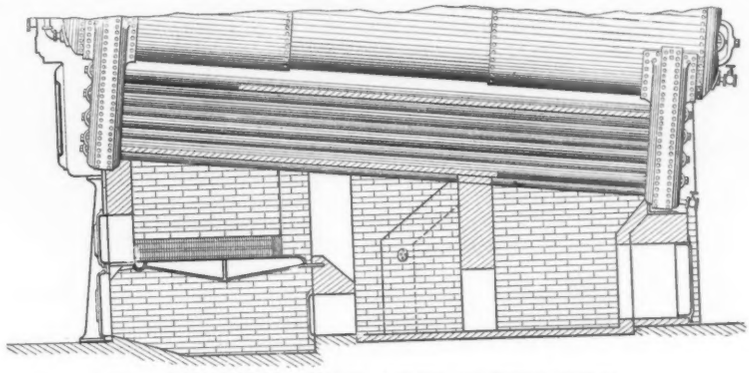


FIG. 1. WOOLLEY FURNACE APPLIED TO HEINE BOILER

indicated by the construction of the fire-box shown in Fig. 1, and the air and gases are in separate strata until they reach the first bridge wall, where they should become partially mixed by reason of this wall being extended to the tubes or boiler on either side, leaving a vertical opening in the center, by means of which the air and gases are caused to converge; thence they pass into the combustion chamber, where they strike the nose of a baffle wall, the diverting planes of which are designed to cause the oxygen of the air to become more thoroughly mixed with the atoms of carbon contained in the gases before reaching the surfaces of the boiler, at a point in the furnace where the boiler will get the benefit of the added heat units evolved by this secondary combustion.

An instance is cited of observations at Washington, D. C., taken with a pyrometer calibrated with the standards of the Bureau of Standards, showing the temperature in the combustion chamber of this furnace to be from 300 to 500 degrees Fahrenheit higher than in the fire-box.

It is pointed out that the boiler can take no heat from the gases as long as they are in the furnace chamber, and that the temperature is sufficiently high in this chamber to keep the brickwork in an incandescent state at all times. The travel of the hot gases is shown by the arrows in Fig. 2.

Another method employed, where the furnace is placed under horizontal water-tube boilers, is suggested by Figs. 3 and 4, which show a method of using encircling tiles for forming the furnace roof. These tiles encircle and are supported by the bottom row of tubes, serving the same purpose as the self-supporting fire-arch used with tubular boilers.

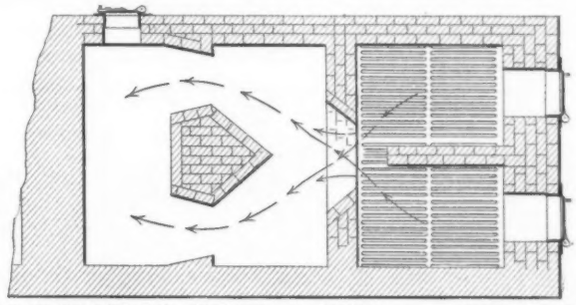


FIG. 2. PLAN OF WOOLLEY FURNACE AS APPLIED TO A STIRLING BOILER

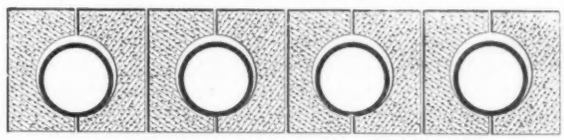


FIG. 3. SECTION THROUGH FURNACE ROOF

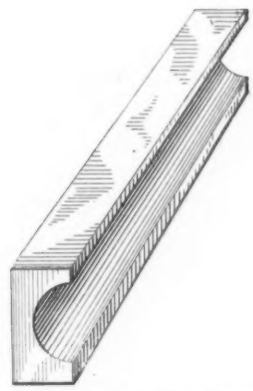


FIG. 4. FORM OF ENCIRCLING TILE

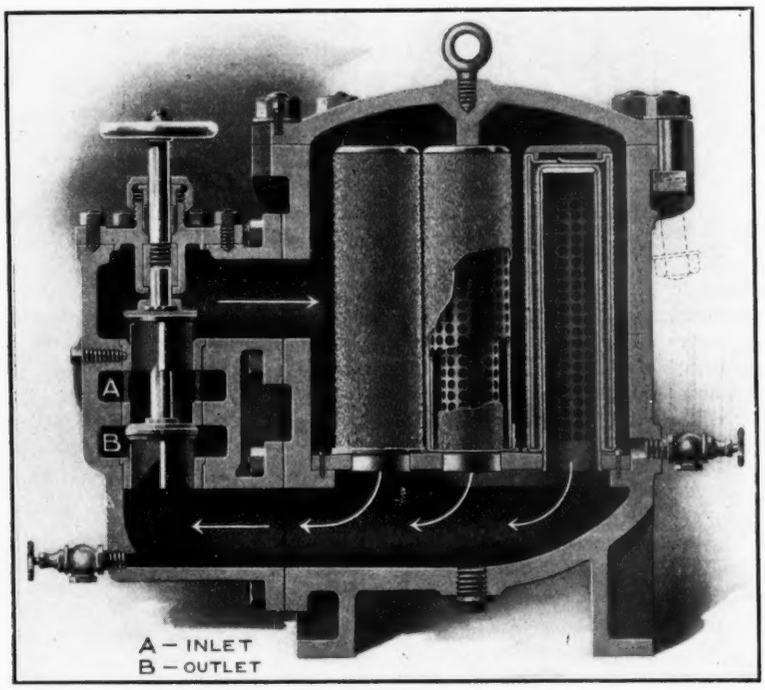
The fire-box is constructed to permit of the alternate method of firing, whereby one side of the furnace is always in an incandescent state, while the other side is being supplied with green fuel. The Woolley furnace may also be installed in connection with mechanical coal-feeding appliances. It is made by the Woolley Smokeless Furnace Company, of Pittsburg, Penn.

An Improved Feed-water Filter and Grease Extractor

The accompanying illustration shows a feed-water filter and grease extractor designed to eliminate foreign matter before it can enter the boiler. The filter is preferably placed between the pump and boiler, so that any desired pressure may be used to force the water through the filtering material. When a closed heater is used, the feed-water is first passed through the filter in order that the matter in suspension may not adhere to the surfaces of the heater and impair their heat-transmitting properties. The upper chamber is separated from the lower by a metal partition, which prevents water in the upper chamber from passing into the lower chamber, except through the filter-

ing cartridges, of which there are from three to eight, according to the size of the unit. These cartridges consist each of two concentric, perforated brass cylinders, so telescoped within linen "Terry" bags that the water must go through two thicknesses to pass from one chamber to the other, thus giving a double filtration.

Water passes through the cartridges at first with but little friction, but in the course of time, as the foreign matter filtered from the water accumulates on the filtering material, more resistance is offered. The amount of this resistance is shown by the readings of two pressure gages, one connected to the filtering chamber and the other to the boiler pressure. When the difference in pressure, as indicated by the gages, exceeds 20 pounds per square inch, the filtering cartridges are removed and others put in; this is accomplished in a few minutes, spare cylinders and "Terry" bags being furnished with each filter.



AN IMPROVED FEED-WATER FILTER AND GREASE EXTRACTOR

Sediment in the bottom of the filtering or upper chamber may be blown through a sludge valve whenever the opening of the valve indicates its presence. The frequency of this, as of the other cleaning operations, varies according to the conditions peculiar to each plant, and the proper cleaning periods are easily determined after the filter has been operated for a short time.

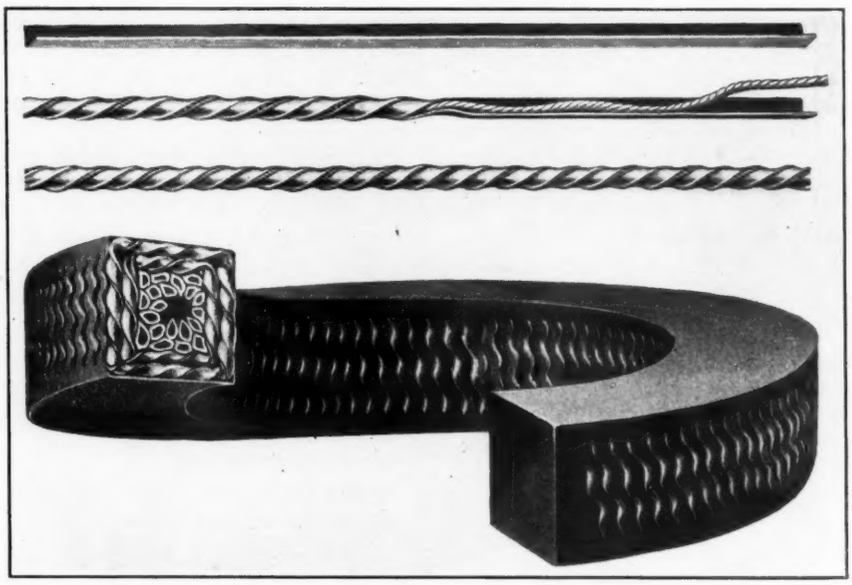
The intake passage communicates with the chamber *A* and the chamber *B* delivers to the outlet of the filter. The main valves are on one stem, so that with one movement of the hand-wheel the filter may be by-passed or opened to full aperture. A water relief valve prevents excessive pressure on the pump discharge line in case cleaning is neglected. A drain and tap for live steam are provided, so that the filtering chest may be "blown out" when it is desirable to clean the interior walls. This filter, known as the "Blackburn-Smith," was patented several years ago, but never extensively manufactured until recently, when James Beggs & Co., of New York, acquired the patents, re-designed practically every part and added new sizes. Six sizes are now manufactured, ranging from three to six inches pipe openings, and capacities from 35,000 to 250,000 pounds of water per hour.

The Federal Flexible Metallic Packing

To make "flexible metallic packing," anti-friction metal is first drawn out into slender V-shaped ribbons, each side of the V being about 1/16 of an inch wide, and twisted around fibrous strands, resembling twine, which are first laid in the trough of the V. The metal thus forms a tube or casing of spiral form with the fiber concealed within. These twisted fiber-stuffed tubes are then made into cores, or braided into cables, convenient for making square or spiral packing, of which they form the base. The core or cable is then covered with a material composed of graphite and other lubricating substances, and compressed into shape for use.

In the accompanying illustration will be seen progressive stages of the manufacture of this packing. First is shown a section of the V-shaped ribbon; next, a section partly twisted, with the fibrous material exposed at one end, and then comes a piece of one of the completed strands. Lastly, the packing is shown slightly opened out, with one end cut off to show the cross-section. It will be noted that a number of short pieces of the twisted material are assembled around a soft, rubber core, and secured by a long strip wound around the outside, to form a cable. Outside of this is seen the composition graphite substance alluded to.

One of the advantages claimed for this packing over the solid, metallic product is its adaptability for use, say around a rod, in the same manner as soft packing, being applied without making any change in the stuffing-box. No springs nor special boxes are required, as it will expand or contract at the same time the rod or box



FEDERAL FLEXIBLE METALLIC PACKING

does, and form a "fit" under any conditions.

As compared with soft packing, it is pointed out that "flexible metallic packing" will wear almost indefinitely, and at the same time possesses elasticity and flexibility, while, from its nature, it will not cut nor score a rod. It is made by the Federal Metallic Packing Company, of Boston, Mass.

A Direct-reading Nozzle Piezometer

The nozzle piezometer is a device for measuring the pressure and quantity of water that is being delivered by a fire stream, test nozzle or other similar outlet. Its aim is to do away with fittings or attachments that must be connected beforehand, and, instead, to read directly both the pressure and the discharge of one or all nozzles without shutting off the water or being obliged to refer to printed tables. As represented in Figs. 1 and 2, the device (which has recently been introduced by the American Steam Gauge and Valve Manufacturing Company, of Boston) consists of a portion called a piezometer, and with it a specially graduated gage. The essential parts of the piezometer section are a semi-circular shield, a form of Pitot tube, a special form of "cutwater," a three-way cock and an attachment for taking static pressures.

Water enters the Pitot tube in the cutwater and the pressure is transmitted through a small bent tube and three-way cock to the direct-reading gage. The shield serves to keep the cutwater within the stream and to prevent water from spraying and spattering. The whole device can easily be held in position with the thumb and finger, pressure merely being needed to steady it.

The gage gives effective pressure, that is, the full pressure which the water possesses by virtue of the velocity that it has the instant it leaves the nozzle; and since the pressure that is observed is the effective pressure, it becomes possible to graduate a gage that will indicate both pressure and quantity of discharge. In the form shown in Fig. 1 the gage is graduated for 1-inch, 1⅛- and 1¼-inch smooth nozzles, and 1⅛-, 1¼- and 1⅜-inch ring nozzles. This size is compact and of light weight, so that it can be easily carried in a coat pocket. A No. 2 and larger size that is now being put on the market gives the discharge for 1½-, 1¾- and 2-inch nozzles, and the pressure, from which the discharge can readily be computed, for nozzles up to 4 inches in diameter. Fig. 2 shows the back of the gage which contains a table of pounds per square inch, and corresponding gallons discharge and scale of the device.

FIG. 1. NOZZLE PIEZOMETER, SHOWING GAGE AND CUTWATER

As to the accuracy of the nozzle piezometer, the designer, Prof. F. B. Sanborn, of Tufts College, states that tests were made in 1906, and the results published in the *Journal* of the Association of Engineering Societies for July, 1906, showed the error in registration to be 1.7 per cent., as an average for 1⅛-inch nozzles. Recently more complete tests were made at Lowell, Mass., in connection with experiments on meters, the actual discharge being measured by a set of standard nozzles and a mercury column connected to 6-inch piezometer rings. Comparison between this determination and that by the nozzle piezometer showed the average registration of the latter to be 99.3, 100.4, and 99.9 per cent. of the measured amount for 1-inch, 2-inch and 4-inch nozzles, respectively. Tests have also been made with higher pressures and greater accuracy was then found than exists with low pressures, because with low pressures, below 20 pounds, for instance, a stream is not so solid, and friction and cross currents have a greater disturbing influence. For accuracy in such cases, it would appear desirable to use a pressure gage constructed especially for low pressures and then to take several readings in different parts of the stream so as to get a fair average.

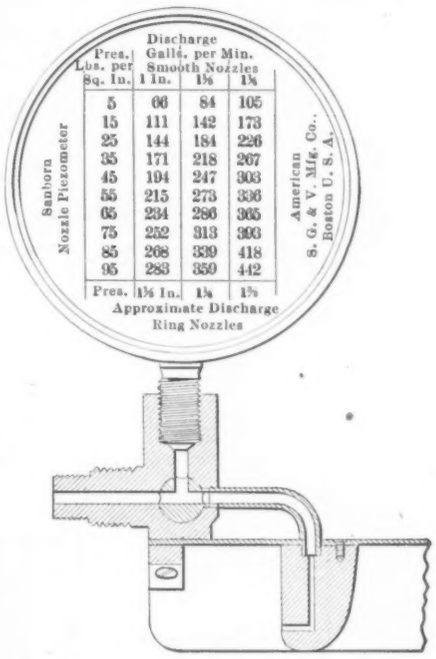


FIG. 2. REVERSE SIDE OF PIEZOMETER GAGE

The Amsler Suction Gas Producer

The Amsler Engineering Company, Pittsburg, Penn., is building a line of gas producers for power purposes, of both the pressure and the suction types. The accompanying engravings illustrate the construction of the suction producer. As Fig. 1

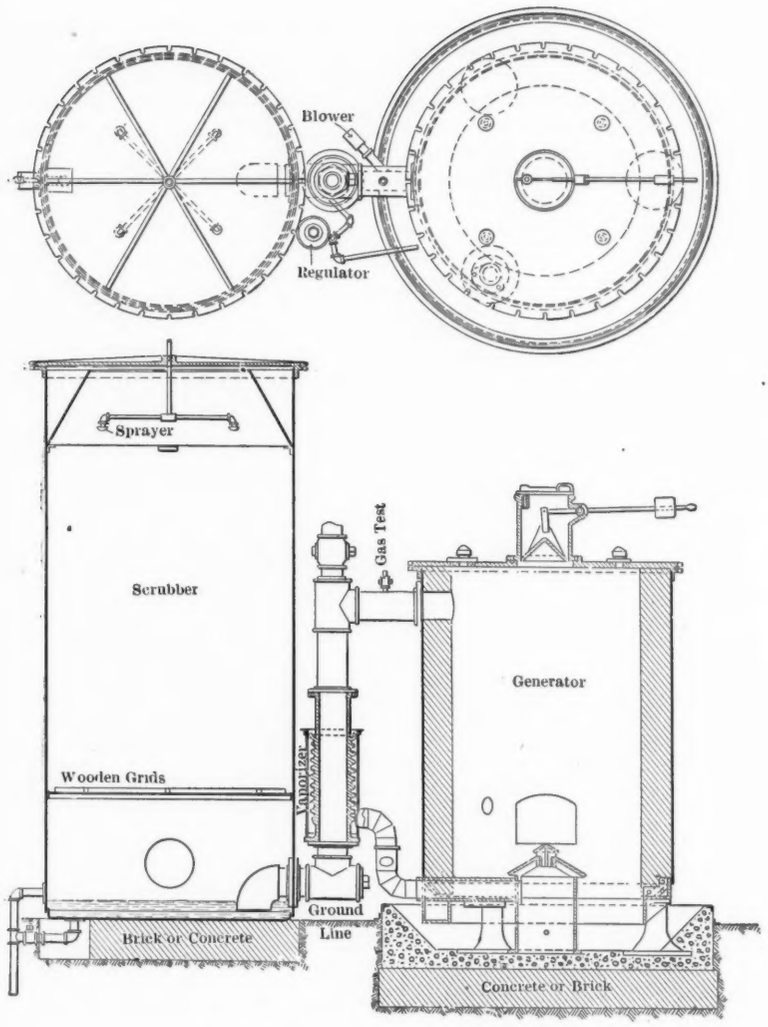


FIG. 1. AMSLER SUCTION GAS PRODUCER

shows, the generator is of the simple cylindrical type, with a central tuyere for the introduction of the air and steam, and water-sealed at the base, so that the ashes may be removed without disturbing the operation of the plant. The tuyere is surmounted by special hoods which are so constructed as to distribute the steam and air over a wide horizontal area and thereby facilitate uniform diffusion throughout the fuel bed. The main hood has a circular opening in the center which is covered by a smaller hood of the same conical form as the main hood; the latter overhangs the mouth of the vertical cast-iron pipe on which it is supported, and part of the steam and air is delivered through the annular space between the end of the pipe and the edge of the hood. A similar annular space is provided at the overhang of the upper hood, and this delivers steam and air to the central part of the fuel bed.

The vaporizer, which is separate from the generator, comprises a piece of cast-iron pipe which is ribbed on the outside for part of its length, and an outer shell which surrounds the ribbed part of the pipe. The upper end of the shell is open to the atmosphere, and the air for the generator is drawn in at this end. The ribs on the inner pipe are spiral and terminate at the top in a shallow trough into which water is delivered to be vaporized. This trickles down the spiral ribbing and is evaporated by the heat from the gas within the pipe, which forms part of the discharge pipe of the generator.

The water supply to the vaporizer is controlled by a simple regulator, the construction of which is illustrated by Fig. 2. A shallow reservoir surrounds two concentric tubes, the outer of which communicates with the reservoir by means of slots near the bottom of the latter. At one side of the reservoir is an overflow weir which keeps the water at a constant level by discharging any surplus into a waste pipe, the water delivery to the reservoir being kept slightly in excess of the demand so as to maintain the level. The inner of the two concentric tubes communicates with the outer tube through a weir which is just a trifle higher than the level of the overflow weir; consequently, when water is passing over the waste weir, it is just level with the edge of the delivery weir, and the least suction will raise it over the weir. The upper end of the inner tube is open, and a pipe from the intake pipe of the engine is tapped into the outer tube near the upper end. When the engine suction causes a partial vacuum in the outer tube (which is closed at the top), the atmospheric pressure on the surface of the water in the reservoir causes the water in the tube to rise above the delivery weir; the water which passes over the weir goes down to an immediate-supply chamber in the bottom of the regulator; from this chamber it flows to the vaporizer through an adjusting valve, a

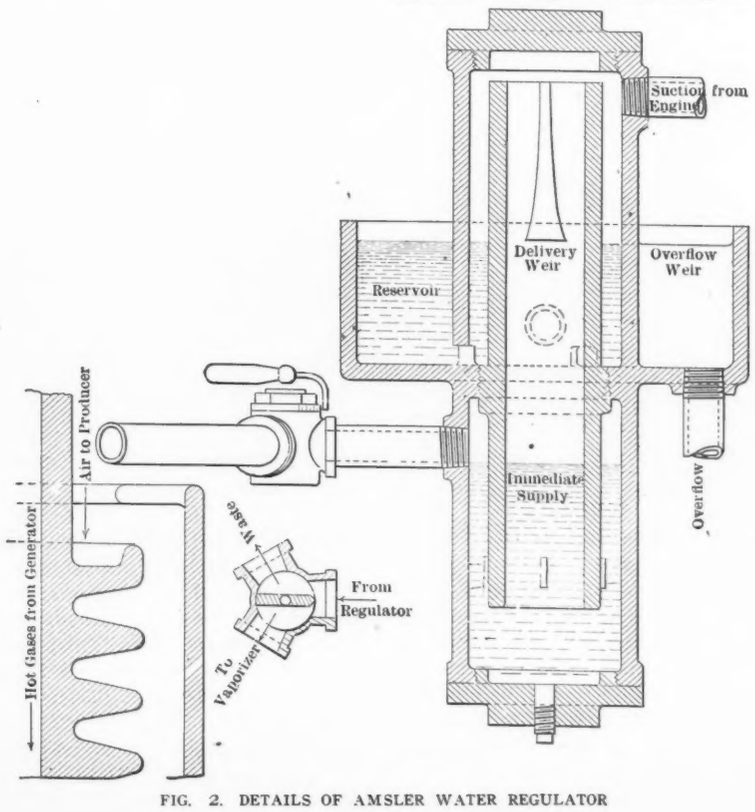


FIG. 2. DETAILS OF AMSLER WATER REGULATOR

cross-section of which is shown below the elevation in the drawing.

From the central pipe of the vaporizer the gas from the generator passes to a wet scrubber of the usual construction. The scrubber is filled with coke which rests on wooden grids and is flooded with water from sprinklers at the top. The scrubber is larger than usual, so as to provide expansion space without the use of a separate tank.

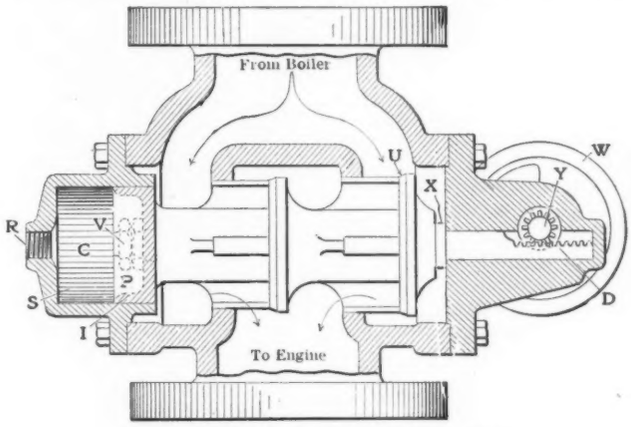


FIG. 1. SECTIONAL VIEW OF MAIN VALVE

The Locke Automatic Engine-stop System

In the Locke system an auxiliary piston *P*, Fig. 1, is used to close the valve through which steam is supplied to the engine. This piston is made about 0.015 of an inch smaller than the cylinder *C* in which it works, so that steam leaks through, and when the outlet to the cylinder *C* is closed the pressure quickly becomes equalized, allowing the valve to remain open.

The outlet to this cylinder is controlled by the electrically manipulated valve, which is the feature of the Locke system. This valve is shown in Figs. 2 and 3. Imagine it connected to the main valve, Fig. 1, as shown in Fig. 4 (the handle may be turned either in line with the inlet connection, as in Fig. 3, or at right angles thereto, as in Fig. 4), and it will be seen that the pressure in *C*, Fig. 1, stands in the chamber *a*, Fig. 3, above the discharge valve and beneath the piston *p*, which is also an easy enough fit for the steam to pass through to the chamber *c* and equalize the pressure on both sides of it, as in the preceding case.

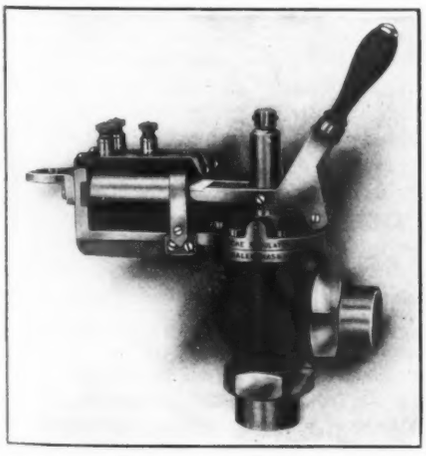


FIG. 2. AUXILIARY ELECTRIC VALVE

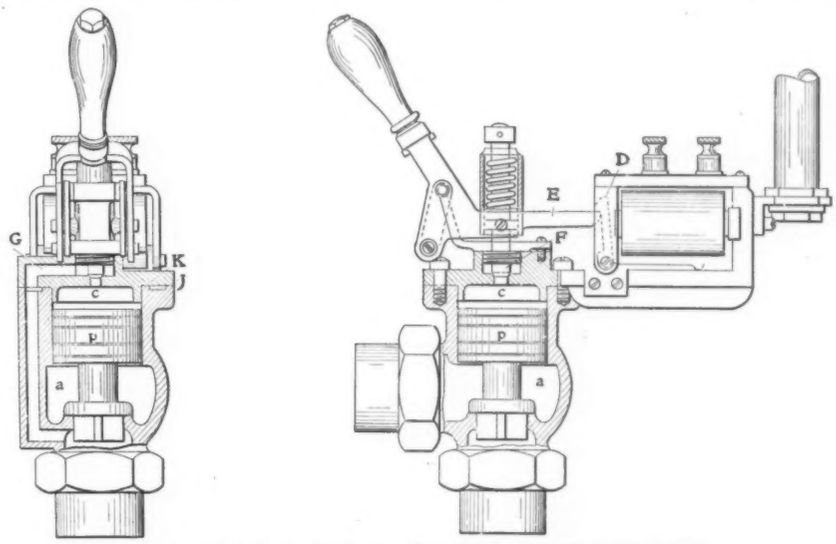


FIG. 3. SECTIONAL VIEW OF THE AUXILIARY ELECTRIC VALVE

When the magnet is energized by the closing of the electric circuit of which its winding is a part, either by the contact points of the emergency "speed limit," or by snapping a switch in the circuit anywhere about the mill, the magnet attracts the armature *D*, releasing the spring which holds the auxiliary valve *F* to its seat, permitting the pressure to force that valve open and to discharge the contents of the chamber *c* through the passage *G* to the outlet. The pressure above the piston *p* being thus relieved, it will be forced from its seat, opening the chamber *a* and thus exhausting the chamber *C* of Fig. 1, and allowing the pressure of the steam to force the main valve to its seat. The auxiliary valve has an annular groove at *J*, which allows any

FIG. 4. MAIN VALVE OF LOCKE SYSTEM

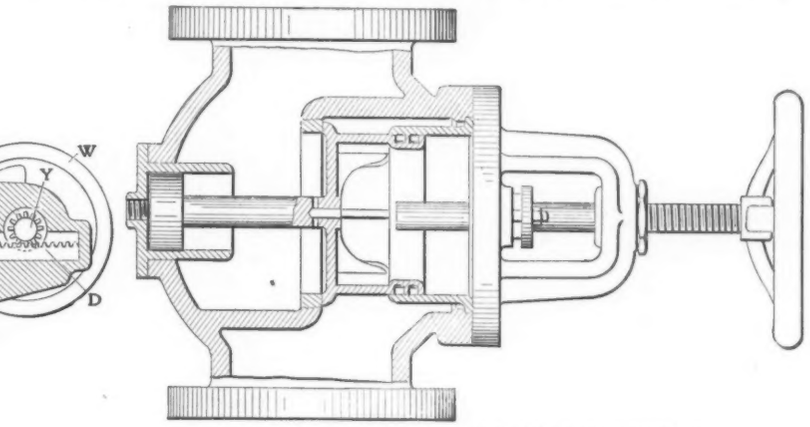


FIG. 7. THROTTLE VALVE FOR LOCKE SYSTEM

condensation which may pass the ground joint *K* to escape to the exhaust pipe through the passage *G*. The main valve is reopened when desired by means of the hand-wheel *W*, Fig. 1, operating the rack and pinion.

These auxiliary valves are directly attached to the main valve, as in Fig. 5, in sizes up to 3½ inches. For the larger sizes they come separately and are attached as shown in Figs. 4 and 6, the one-inch lever globe valve shown between the electric valve and the main valve being provided so that the electrical apparatus can be tested without closing the main valve. The valve is also provided with a stop by which it may be so adjusted as to prevent a too sudden closing of the main valve. Fig. 6 shows the auxiliary valve attached to a stop-valve which may be placed in the main line near the boilers, so that all the engines of the plant are brought under its control. Fig. 7 shows a throttle valve arranged for the use of the engine-stop. The main valve is opened by the steam pressure, forced to its seat by the screwed stem or by the auxiliary piston when the electrically controlled valve is operated.

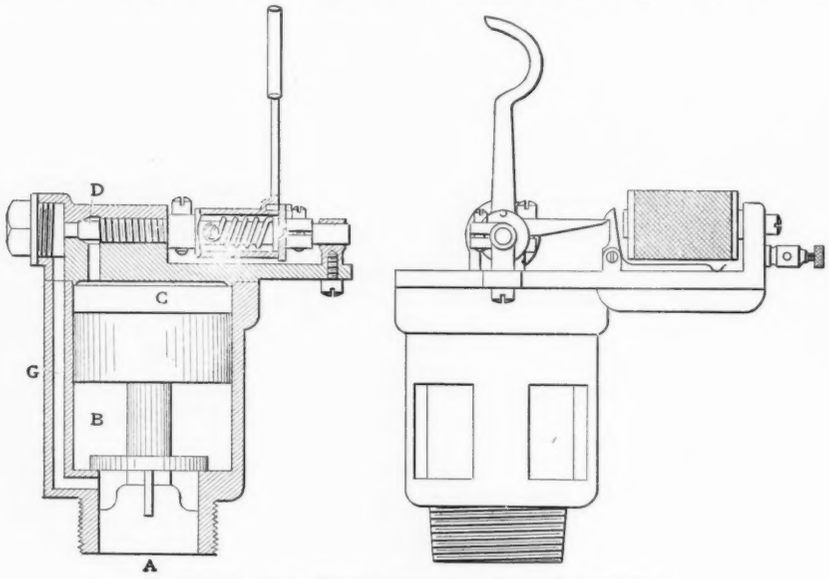


FIG. 8. THE LOCKE AUTOMATIC VACUUM BREAKER

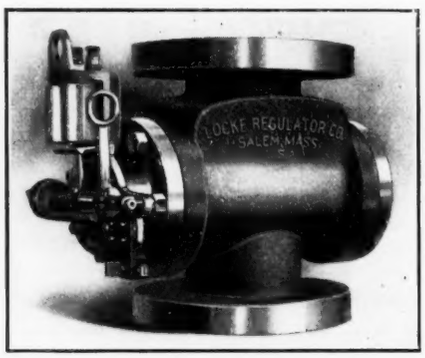


FIG. 5. AUXILIARY VALVE DIRECTLY ATTACHED TO MAIN VALVE

FIG. 9. LOCKE VACUUM BREAKER

Figs. 8 and 9 show a vacuum breaker which operates upon the same circuit and principle. The valve is connected with the condenser at *A;* atmospheric pressure stands in *B* and *C*. The tripping of the latch opens *B*, connecting the chamber *C* to the condenser through the passage *G*, upon which the excess pressure in *B* opens the valve, admitting air to the condenser.

The Locke Regulator Company, Salem, Mass., is the manufacturer.

Schmid's Automatic Free-exhaust Relief Valve

A feature of the Schmid automatic free-exhaust relief valve is the facility with which access to the parts can be had while the valve is in position on the pipe line, without disturbing any of the connections. Referring to the illustration, it will be seen that a cover *A* can be removed, giving ample and direct access to the valve. The valve seat is located below the cover opening, so that on removing the cover the water which forms the water-seal for the valve will not flow from the opening. When it is desired to raise the valve disk from the seat by outside means, and hold it open indefinitely, air or water pressure is employed, although if desired gearing can be provided, to be operated by a lever or a hand-wheel and chain. Water or air pressure is applied at the port *B*, which communicates with the upper dash-pot, and raises the valve from its seat. When the maximum of the stroke is reached the bottom of the piston *C*, which has a beveled seat, meets a corresponding seat on the valve and dash-pot (shown at *D*),

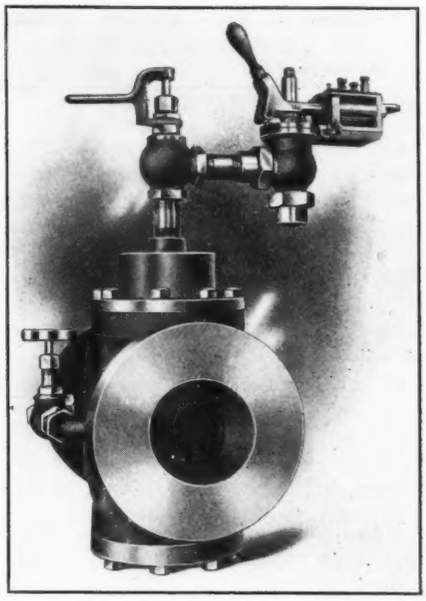
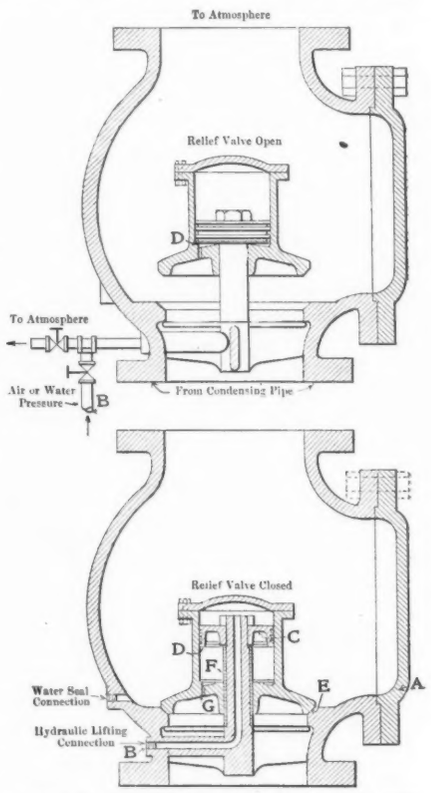


FIG. 6. TYPE OF MAIN VALVE FOR HORIZONTAL LINES

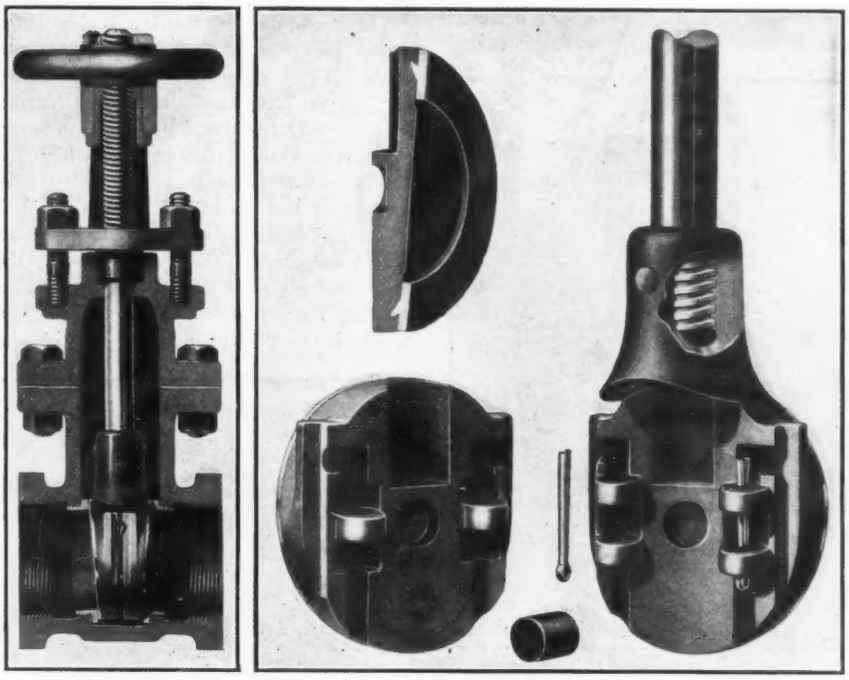
making a tight joint, without the aid of packing rings or glands. About five pounds water pressure is sufficient to hold the valve open, it is stated, and by applying the water pressure as required the valve disk can be raised or lowered when grinding in the seats, without unsettling the parts.



SCHMID'S VERTICAL AUTOMATIC EXHAUST RELIEF VALVE

There are no sliding surfaces above the valve to corrode, and thus interfere with its operation. The valve is guided directly opposite the valve seat *E* on a spindle with a removable sleeve held in position by spiders, as shown at *F*, and the guiding and sliding surfaces are housed in and protected. Any water accumulating in the bottom of the valve will drain into the exhaust pipe through a small hole *G*. In opening automatically, when the vacuum fails, the valve is restrained from hammering or chattering by the dampening action of the dash-pot above it.

Schmid valves are made in globe, angle, vertical and special types, as desired. The parts are the same for all valves of the same size. The patentee and manufacturer is John V. Schmid, 1823 W. Allegheny avenue, Philadelphia, Penn.



SECTIONAL VIEW AND DETAILS OF PITTSBURGH GATE VALVE

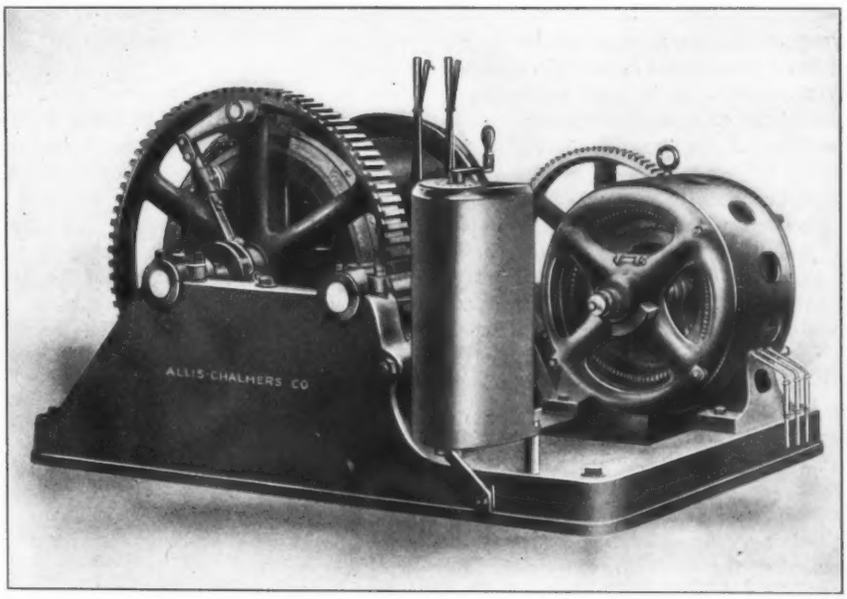
The Pittsburgh Gate Valve

The leading thought in the mind of the designer of this valve was to realize the advantages of the double gate, and at the same time to employ a wedge which would not drag and abrade the seats in opening and closing. These advantages of the solid wedge and the loose disk are secured by making one of the disks a solid wedge, rigidly attached to the stem, and hinging the other disk to the attached one in such a way, shown by the accompanying engraving, as will allow both to adjust themselves to the seats; and as the disks are guided by ribs cast in the body of the valve they lift fair away from the seats without scraping, although the guides do not interfere with the valve finding its seat however distorted. The construction will be apparent from the engraving without much description. The outside-threaded stem is screwed and pinned into the collar which is integral with the right-hand wedge in the sectional view. This wedge has cast upon it the bosses shown in the face view, which span the interlocking single bosses on the loose disk. These bosses are drilled and pinned together with cotter pins, so loosely that they can move in either direction upon the plug which is set loosely into the central pocket in both disks, and adapt themselves to the seats whatever the conditions may be as to parallelism or cleanliness. The plug is made of such length that the wedges seat in the highest position which would give lap enough to make a tight closure, giving the maximum amount of wear before the wedge will bottom.

In the iron-body valves the wedges are faced with steam metal, which is forced into an undercut groove in the face of the disk, by a special machine using rolling pressure, which at the same time compacts and surfaces the metal. The seats are forced in from the inside. The projection on the side of each disk makes, when the disks are pinned together, a pair which span the guide cast in the center of each side of the body. The thread upon the stem is a double Acme. The valve is put together with through bolts, the only studs used being those of the packing gland, and the bracket in which these are set is reinforced to give them ample hold. It is made by the Pittsburgh Valve and Fittings Company, Barberton, O.

Allis-Chalmers Electric Hoists

Allis-Chalmers Company, Milwaukee, has recently brought out a line of electric hoists designed to work under approximately the same conditions as its well known small steam-driven hoist. The single-drum electric hoists are of 15, 25, 35, 50 and 75 horse-power capacity, and double-drum hoists are made in 30, 50, 75, 100, 125 and 150 horse-power sizes. The rope speeds and load capacities have been chosen to meet average requirements, and special attention has been given to insuring reliable and economical operation.



ALLIS-CHALMERS ELECTRIC HOIST

The drum (or drums) and motor are mounted upon a substantial bed-plate of box section, with broad bearing surface on the foundation. The bearings are carried on pedestals cast in one piece with the bed-plate, so that there are no bolts to work loose, and the proper alinement

of the machine is thus maintained at all times. The bearings of each hoist are all of the same length and diameter, lined with babbitt metal. Ample provision is made for thorough lubrication and the bearings are made of such size as to obtain a very low bearing pressure.

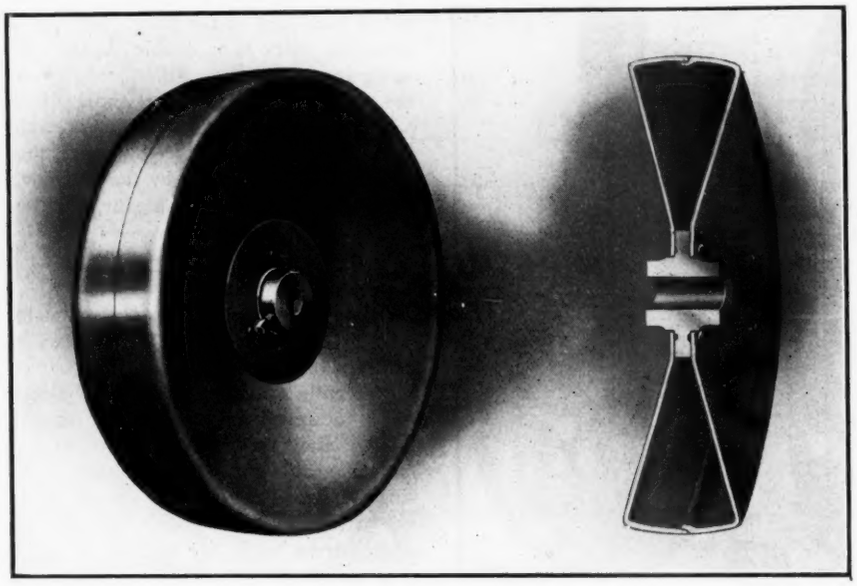
The drum runs loose on the shaft and is made in one piece, of cast iron. The spider hubs are fitted with bronze bushings which can be readily replaced in case of wear. The drum spiders have ribbed arms, and the drum shell is reinforced by deep circular ribs. The hole in the shell through which the rope passes for fastening has a long-radius curve, thus avoiding any sharp bend in the rope and reducing the tendency to rope breakage at this point. The face of the drum is straight, not grooved.

The brake is of steel-band type, and is provided with turnbuckle adjustment for taking up the wear on the brake blocks. One end of the brake band is anchored by eye bars around the operating shaft and the other end is attached, through a turnbuckle, to a lever on the shaft controlled by the operator's hand lever.

The main gear, keyed on the drum shaft, forms the driving member of the clutch, which is of the friction band type. The fixed end of the band is fastened to the driving gear and has adjustment for shortening the band to compensate for wear. The movable end of the band is actuated by a toggle lever, motion to which is imparted by a collar sliding on the drum shaft and controlled by the operator's hand lever through suitable connections. When the clutch is thrown in, the band is tightened around the drum shell by the toggle motion, and the pull of the rope on the drum tends to still further tighten the grip of the band on the shell. Both the band-friction clutch and the band brake are hand operated and the operating levers are provided with quadrants and locking pawls.

The large gears are cast of a special mixture of tough iron with heavy rims, arms and hubs; the pinions are of cast steel; the teeth of both the wheels and the pinions are cut. When desired, the pinion on the motor shaft is made of rawhide at a small additional cost.

For driving these hoists, either direct-current or alternating-current motors, wound for the usual voltages, are employed; if alternating-current, either 25-cycle or 60-cycle machines. The controllers are of the drum type, similar to those in common use on street cars. On all single-drum hoists the motor is not reversed, but on double-drum hoists the handle of the controller not only controls the speed but also reverses the motor, and is locked in the "off" position. The controller is attached to the frame of the hoist, and if desired the lever of the controller can be made of the same design as the brake and clutch levers. The accompanying engraving shows a single-drum alternating-current outfit.



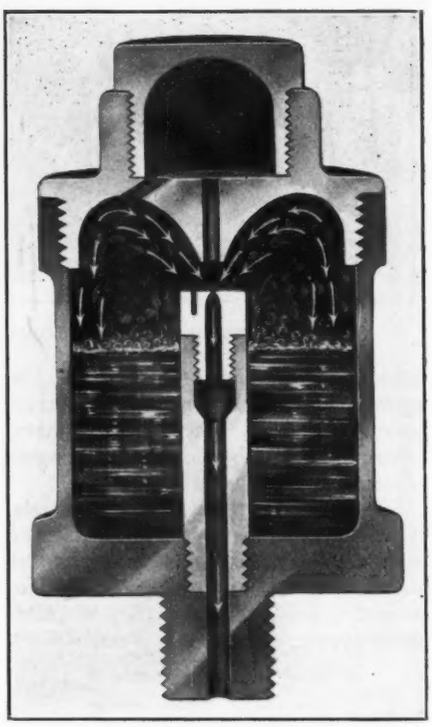
A NEW STAMPED STEEL PULLEY

Stamped-steel Pulleys

We show herewith a new-style pulley, especially suitable for a high-speed guide pulley, which on account of its smooth surface is not liable to injure belt or band. It has been recently put on the market by Walker & Holroyd, of Bradford, England. These pulleys are constructed of two drawn-steel stampings, each concave and evenly balanced, one half having a lip into which the edge of the other half fits, a form of construction which affords sufficient rigidity, so that no other support is required between boss and rim. The boss is of cast iron and is riveted in place. It is conceivable that these pulleys are considerably lighter than ordinary cast-iron pulleys, and that the concave formation and the absence of ledges prevent the accumulation of "fluff" or nap.

The Bangs Automatic Oil Cup

The accompanying sectional view illustrates the principle of the Bangs automatic oil cup, type A5, which is designed for use on crossheads, eccentrics, crankpins or other reciprocal bearings. The reciprocal motion of the part to which the cup is attached causes the oil to be thrown to the top of the cup, when it is directed downward and part of it is naturally deflected to the feeder hole by the radial-curve guides shown, the arrows indicating the direction the oil takes. The result is that a particle of oil is distributed to the feed-duct by each stroke, and the greater the speed the greater, or more frequent, the feed.



THE BANGS AUTOMATIC OIL CUP

The feed-duct is so shaped, with the opening at the top smaller than the rest, that the least sediment that enters the opening will pass on through the duct, and the agitation of the oil will prevent the accumulation of sediment above the duct opening. When the engine stops, the flow of oil will stop. The plug in the cover may be removed for the purpose of filling the cup, or, if preferred, a spring cap can be substituted which will permit filling the cup without stopping the engine.

It is understood that the same design, with slight modifications, has been applied

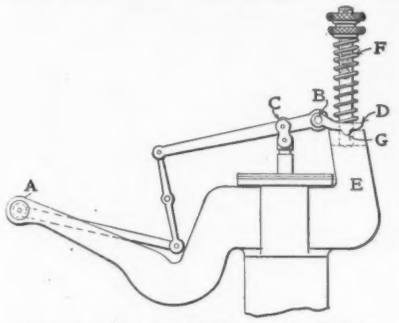
with success to cups for stationary bearings.

These cups are made of aluminum, brass or iron, no glass being used. They are manufactured by the Automatic Oil Cup Company, Milwaukee, Wis.

Atkinson's Indicator Attachment

The accompanying illustration explains the application of an indicator attachment recently patented by James Atkinson, of Glenburn, Mellor, near Stockport, England. The device comprises a spring attached to the multiplying gear of an indicator for the purpose of taking up sudden vibratory movements of the indicator piston, controlling the pencil and causing it to register a more uniform line. In the illustration the device is shown as applied to a "Richards" type of indicator, although it is applicable to other types.

The spring is attached in such manner that excessive strains will cause a slight up or down movement to the fulcrum *B*, which is attached to a separate piece *D*, instead of to the arm of the swiveling piece *C*, as is usual. The separate piece *D*



ATKINSON'S INDICATOR ATTACHMENT

is held down to the arm *E* by means of an adjustable spring *F*, the arm *E* being shown with a flat surface, on which the piece *D* rests. The piece *D* has a projecting portion *G*, which fits into a groove in the arm *E*, definitely fixing the position of the joint *B* longitudinally. Its under side is flat around the center, but curves upward at the edge.

It will be noted that excessive pressures on the system of levers at *C*, either up or down, can cause the separate piece *D* to rock and allow the center *B* to also move up or down. When, however, the excessive pressure falls, the flat portion of the piece *D* rests definitely on the flat surface of *E*, and the center *B*, forming the system of levers, is then fixed. The pressure on the spring *F* may be adjusted so that it has a different period of vibration from that of the spring in the indicator, to enable the pencil to draw a steadier line.

The Monitor Water Purifier

The Monitor water purifier is an open heater of the pan type, using circular cast-iron pans, one of which is shown in Fig. 1. These pans fit into each other in a nest as shown in Fig. 2, each being supported by downwardly projecting legs, and the lower pan resting on lugs riveted to the shell. Their situation in the purifier is shown in Fig. 3.

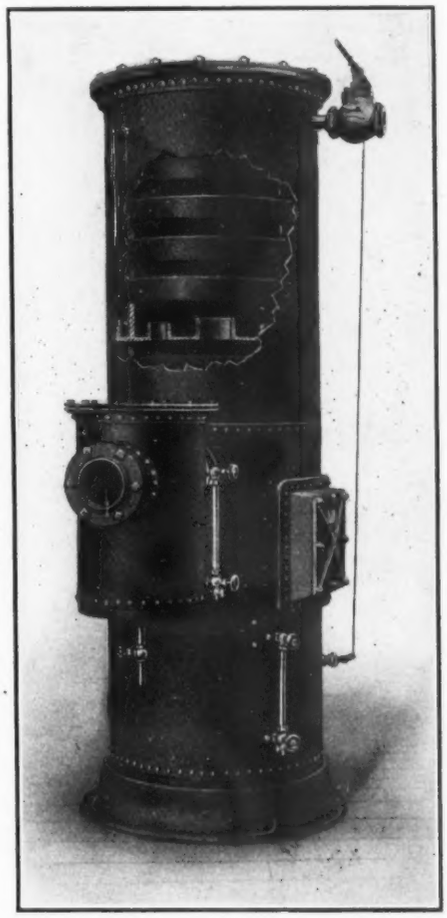


FIG. 3. THE MONITOR WATER PURIFIER

Steam enters at the nozzle at the left in Fig. 3 and passes first through a Monitor oil extractor. Entering the heating portion of the purifier, it passes upward through the nozzles in the pans, those in a 150-horse-power purifier being about

FIG. 1. ONE OF THE PANS

four inches in diameter. The water enters near the top of the purifier, fills the top pan and overflows into the one below it, which in turn overflows, the operation being continued until the water flows from the lowest pan onto the filtering bed, through which it passes to the settling chamber in the base of the apparatus. The water is thus exposed to the action of the steam in a thin sheet and is heated to a temperature which causes the substances which it carries to be deposited in the pans themselves and in the insides of

FIG. 2. SHOWING PANS ASSEMBLED

the nozzles, which are frequently reduced by scale deposits to an inside diameter of an inch and a half.

Either coke or quartz, in sacks, loose excelsior or hay may be used as a filtering material. The makers recommend either of the two latter, owing to their cheapness and the facility with which they may be handled and obtained. The bottom of the purifier is made concave, thus affording an ample settling chamber, tapped at its lowest point for a blow-off

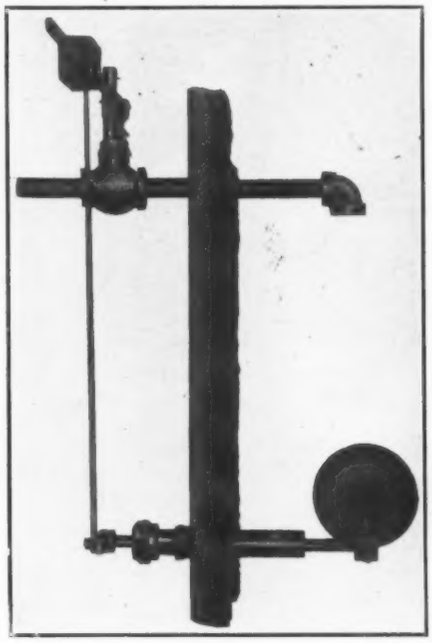


FIG. 4. AUTOMATIC WATER REGULATOR

pipe. Above the concave head or bottom is placed a hot-water outlet, which is connected to the boiler feed-pumps.

The admission of water to the purifier is regulated by a ball and float, shown in Fig. 4; the float, being inside the purifier proper and not in an outside chamber, is

instantly affected by any variation in the water level, and controls in an obvious manner a balanced valve which controls the supply of water to the upper pan. This regulating device is adaptable to a number of uses besides that for which it is here shown, and is to be obtained separately from the purifier. The purifiers are made in capacities of from ten to one thousand horse-power by the Jarvis Engine and Machine Works, Lansing, Michigan.

Massachusetts N. A. S. E. Convention

The twelfth annual convention of the Massachusetts State Association, N. A. S. E., was held at New Bedford, Mass., July 12 and 13. The business sessions were held in Odd Fellows' building, while in an adjoining hall in the same building the supplymen held a large and excellent exhibit. In point of attendance this gathering was the largest in the history of the State association.

The convention was called to order with State President Eli Haworth in the chair. Preliminary to the opening Mr. Haworth was presented a gavel by F. W. Carter, chairman of the local committee. Acting Mayor Samuel Highman welcomed the delegates and gave them and their guests the freedom of the city. National President T. N. Kelsey responded for the engineers. State Senator W. J. Bullock delivered an address, which was heartily received, and Joseph F. Carney, national vice-president, spoke briefly of the benefits of membership in the N. A. S. E.

The election of officers resulted as follows: George E. Leavitt, president; Ole B. Petersen, vice-president; James H. Sumner, secretary; Walter H. Damon, treasurer. Haverhill, Mass., was selected for the next convention in July, 1908.

Besides trolley trips and visits to the principal plants, the local committee provided a banquet on Friday evening, which proved to be the crowning social feature. The ladies were invited and every seat in the spacious dining hall was filled. F. L. Johnson made a most agreeable toastmaster, and introduced the following interesting speakers: Congressman W. S. Greene, State Senator W. J. Bullock, National President T. N. Kelsey, National Vice-president Joseph F. Carney, Past National President P. H. Hogan, W. W. McLane, G. E. Leavitt and O. B. Petersen. The speeches were interspersed with songs and recitations by Edward Noonan, Thomas Wheelan, Thomas Crowley and "Jack" Armour.

MASSACHUSETTS STATE CONVENTION, N. A. S. E., AT NEW BEDFORD, JULY 12 AND 13

N. A. S. E. Annual Convention

The twenty-sixth annual convention of the National Association of Stationary Engineers will be held at Niagara Falls during the week beginning September 9. The exhibits promise to eclipse all former displays, both in number and attractiveness, and the several committees are working assiduously to make it the best convention in the history of the association. The arrangements are practically complete.

Exceptional entertainment features are promised, including automobile rides about the city and to the falls, inspection of the National Food Company's plant, an informal dance, a steamboat trip to Toronto, a vaudeville performance, and on the last night (Friday) a ball at the Cataract House.

At Toronto the visitors will be the guests of Canadian engineers, and on the return trip the beauties of the gorge will be viewed by searchlight.

Connecticut N. A. S. E. Convention

The Connecticut State Convention of the National Association of Stationary Engineers was held at Ansonia, Saturday, July 7. The convention was opened with prayer by Rev. C. M. Gross. The address of welcome was delivered by Mayor Stephen Charters, and was responded to by National President T. N. Kelsey. State Secretary C. D. Osborne spoke briefly but earnestly on the social feature of the N. A. S. E., and National Vice-president Joseph F. Carney explained the benefits and objects of the organization. The annual address of State President J. J. McManus was received with favor.

After the regular business was cleared up the convention adjourned to meet at Norwich, Conn., on the second Saturday in July, 1908.

The election of officers resulted as follows: William Clark, president; George Thomas, vice-president; C. D. Osborne, secretary-treasurer; J. H. Gaffney, conductor; George Cleveland, doorkeeper; W. B. Holt, Joseph Bellwood, Fred McGar, trustees. "Jack" Armour entertained and there were good things to eat, drink and smoke in abundance. R. S. Gray was the master of ceremonies.

The CO_2 Motor

Philadelphia is excited over a CO_2 motor. A few cents' worth of carbonic-acid gas is put into a cylinder and is supposed to run an engine until it is lost by leakage, a month or more, according to the condition of the stuffing-boxes.

The A. I. E. E. Convention at Niagara Falls

The twenty-fourth annual convention of the American Institute of Electrical Engineers was held at Niagara Falls, N. Y., June 25 to 28, inclusive, and was well attended, as the accompanying picture indicates; the photograph does not include all who were at the convention. President-elect H. G. Stott is at the extreme left of those in the front row—at the right-hand lower corner of the picture. Near the center, with his inevitable cigar, is Dr. Charles P. Steinmetz, chief engineer of the General Electric Company.

The papers read at the convention were devoted largely to transmission subjects: "Transmission Line Towers," by D. R. Scholes; "Transmission Line Protection Against Lightning," by Norman Rowe; "Transmission Line Troubles," by L. C. Nicholson; "One-phase High-tension Power Transmission," by E. J. Young, and "Power Transmission Economics," by F. G. Baum, being among those presented.

SOME OF THOSE PRESENT AT THE A. I. E. E. CONVENTION

To Obtain Lubricating Oil From Crude Oil

A patent has been issued to William J. Ryan and Charles R. Burg for a process of obtaining lubricating oil from crude oil, mainly applicable in the production of lubricating oils of a very low cold test. The process consists in chilling the crude oil to be filtered to a temperature of from — 10 to 40 degrees Fahrenheit, and passing it through a filter surrounded by brine or a similar cooling medium, so that the low temperature is maintained. At this temperature much of the waxy and gummy material is sufficiently solid to be retained by the filter and the color of the oil may be regulated by the depth of filtering material. If the crude oil possesses a specific gravity of more than 35 degrees Baumé, it is necessary to dilute it by naphtha, alcohol, or some such material, which may be driven off subsequently in order to regulate the flash test.

We had the pleasure of attending one of the "demonstrations," too late to report at length in this issue. It was one of the best farce comedies that we have seen off of the stage, and would not have misled a schoolboy who had a working knowledge of physics. The stock is being advertised broadly and there are rumors that the automobile privilege has been sold for two million dollars.

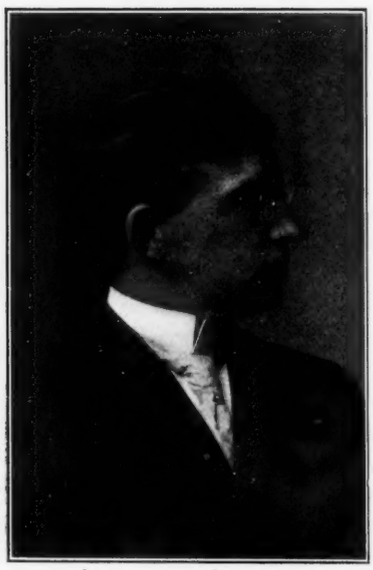
It is only necessary to reiterate that no machine can give out more energy than is put into it, and the alleged "inventor" utterly fails to controvert this mechanical truth to the satisfaction of anyone of ordinary intelligence.

A 20-ton fly-wheel in the Joliet (Ill.) plant of the American Can Company burst July 10, killing one employee, injuring another and doing considerable damage to property. There was no safety-stop system.

Recently the jury before which was tried the case of the superintendent and assistant superintendent of the Shelby Steel Tube Company, charged with conspiracy to defraud the Government by the alleged installation of defective boiler-tubes in warships, announced that its members were unable to agree, and they were discharged.

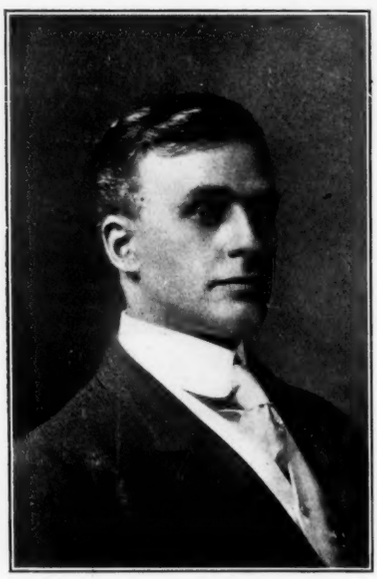
The Massachusetts Board of Boiler Rules

One of the recent enactments by the Massachusetts legislature is an amendment to the boiler-inspection law, which, in addition to giving the State boiler inspection department jurisdiction over all boilers in the Commonwealth, provides for the appointment by the governor of a "Board of Boiler Rules." These appointments have been made as follows:



FREDERIC H. KEYES
Representing boiler manufacturers.

Joseph H. McNeill, chairman of the board, has been successively an apprentice, draftsman, journeyman, marine engineer, stationary engineer and master mechanic. In 1898 he entered the boiler-inspection department of the Massachusetts district police as an inspector of boilers and examiner of engineers and firemen, and in September, 1906, he was appointed chief inspector.

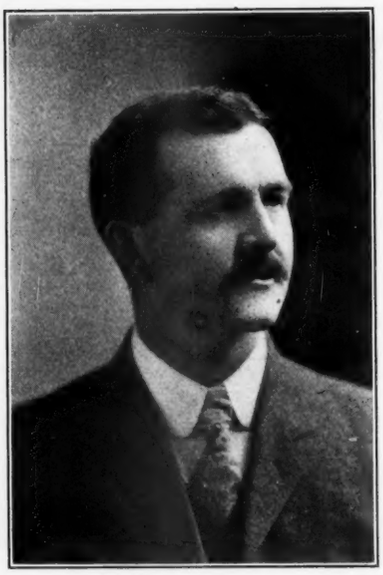


JOHN A. STEVENS
Representing the boiler-using interests.

John A. Stevens, M.E., represents the boiler-using interests. After graduating from the University of Michigan, Mr. Stevens served an apprenticeship as a machinist with Mitts & Merrill, Saginaw, Mich. He then took up marine engineering on the Great Lakes, and seven years later entered the employ of the International Navigation Company, being rapidly promoted to the position of first assistant engineer of the United States mail steamship "Saint Paul," which position he resigned in 1896 to become chief engineer of the Merrimac Manufacturing Company, of Lowell, Mass.

Mr. Stevens is a member of the American Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers and the National Association of Cotton Manufacturers.

Frederic H. Keyes, who represents the boiler-manufacturing interests, was indorsed by the New England Boiler Manufacturers Association. He graduated from the Massachusetts Institute of Technology as a mechanical engineer. He was connected with the Turner Brass Works, of Chicago, and the American Tool and Machine Company, of Boston, for one and a half years, after which he returned to the Institute of Technology as instructor in mechanical engineering. He was next employed by the engineering firms of J. R. Worcester and Stone & Webster, until six years ago he entered the employ of the Robb-Mumford Boiler Company, and is now general manager of its works.



JOSEPH H. MCNEILL
Chairman.

Mr. Keyes is a member of the American Society of Mechanical Engineers.

Robert J. Dunkle, in 1890, became associated with an insurance agency in the South, doing largely boiler and liability insurance, and in 1893 he went to Boston to engage in the same line. In 1895 he became manager for New England of the Union Casualty and Surety Company, of St. Louis. In 1898 Mr. Dunkle became associated with O'Brien & Russell in the management of their liability, accident and boiler insurance business, and in 1901 he was admitted to a partnership in the firm.

WILLIAM M. BECK
Representing operating engineers.

William M. Beck's appointment was made under the clause of the law that one member shall be an operating engineer. For the past 15 years Mr. Beck has been employed as a stationary engineer, principally with the Faxon Company and the Vose Piano Company, of Boston, having held the position of chief engineer of the latter company since 1895.

ROBERT J. DUNKLE
Representing boiler-insurance interests.

As a member of Bay State Council, American Order of Steam Engineers, Mr. Beck took a prominent part in educational work and license-law legislation. Since

1896 he has been a member of No. 12, N. A. S. E., of which he is past president, and he has also been on the board of trustees. In 1904 Mr. Beck was active in the organization of Union 263, of Boston, International Union of Steam Engineers, of which he is also past president. He is now State president for Massachusetts, and chairman of the executive board, of the International Steam Engineers, and chairman of the license-law committee, N. A. S. E.

Convention of the International Association for the Prevention of Smoke

This association, organized one year ago at Detroit, has a membership of about 65, of which 18 or 20 are active, the remainder associate members. Previous to the Milwaukee meeting the dues were $2 per annum for the active, with no dues nor initiation fee for associates.

At the Milwaukee meeting, held in the council chamber of the City Hall, June 26, 27 and 28, 1907, the following cities were represented by their smoke inspectors or health officials: Chicago, Ill.; Cleveland, O.; Dayton, O.; Denver, Col.; Detroit. Mich.; Grand Rapids, Mich.; Harrisburg, Penn.; Indianapolis, Ind.; Milwaukee, Wis.; Rochester, N. Y.; Syracuse, N. Y; Toledo, O; Toronto, Can.

One of the most important items of business transacted was the passage of a resolution suggesting uniformity in the laws of States, under which municipalities operate, so that a more definite and uniform municipal ordinance may be employed.

Another important item was raising the dues of the active members from $2 to $5 per annum, and charging the associate members a like sum, this being a most valuable piece of legislation, because it will furnish the association a fund with which to carry on its work, one of the serious difficulties of the past situation being that there would be no funds for the printing of papers or the issuance of a journal giving the results of the society's work.

The meeting was particularly fortunate in having present three of the leading experts in the country on smoke: Prof. L. P. Breckenridge, A. Bement and Prof. Wm. Kent, the latter of whom gave an interesting account of methods suggested by him to obviate the smoke nuisance in the plants of the New York Edison Company. Professor Breckenridge described the smoke-proof boiler furnace employed by the engineering experiment station of the Illinois State University, which is an apparatus of the same character as that which has been in use at the Harrison street station of the Chicago Edison Company for several years and Mr. Bement described the process of smokeless combustion which he has recommended in papers before the American Society of Mechanical Engineers and elsewhere (see POWER, page 43, January, 1907).

The following officers were elected for the ensuing year: President, Charles Poethke, Milwaukee; vice-president, John Krause, Cleveland; secretary-treasurer, R. C. Harris, Toronto.

It is probable that the membership of this association will become very much larger, and that it will accomplish much good.

The next meeting of the association will be held the last week in June, 1908, at Cleveland, Ohio.

Universal Craftsmen's Convention

The fifth annual convention of the Universal Craftsmen Council of Engineers will be held at Chicago, Ill., August 6 to 10. Oriental and drill halls, in the Masonic Temple building, have been secured for the convention, and elaborate arrangements have been made in the way of entertainment, which will include a moonlight trip on Lake Michigan on the excursion steamer "Theodore Roosevelt," on which occasion there will be a fine vaudeville program and dancing. There will be a large number of exhibits and many representatives of supply houses will attend. Altogether this convention bids fair to be the largest ever held by the society.

A. S. M. E. Meetings

The monthly meetings of the American Society of Mechanical Engineers will be resumed on October 8, and will be held on the second Tuesday of each month during the winter, with the exception of December, during the first week of which occurs the annual meeting of the society. The meeting of October 8 will be addressed by Prof. John P. Jackson, of the Pennsylvania State College, upon "The Relation of the College Technical Course to the Apprenticeship Course in Industrial Establishments." Prof. Dugald C. Jackson, of the Massachusetts Institute of Technology, and president of the Society for the Promotion of Engineering Education, and Dr. Henry Pritchett, president of the Carnegie Foundation and of the American Society for the Promotion of Industrial Education, will address the meeting. On November 11 Charles R. Pratt will read a paper on the elevators of the new Singer and Metropolitan Life Insurance buildings. The gas-engine and foundry practice will be the leading topics of the annual meeting in December.

Personal

C. M. Harris has been appointed master mechanic and J. B. McIntosh superintendent of heat, light and power of the Washington Terminal Company, Washington, D. C.

V. R. Hughes has resigned as chief engineer of the Pueblo & Suburban Traction and Light Company, to assume a similar position with the Northern Colorado Power Company, of Lafayette, Colo.

H. A. Leffert, for eight years chief engineer at the Hotel del Coronado, Coronado Beach, Cal., has been appointed master mechanic at the shops of the National City & Otay Railroad, National City, Cal.

Frederick A. Waldron has opened offices at 37 Wall street, New York City, for the conduct of his profession as industrial engineer. Mr. Waldron will make a specialty of reporting and advising on the planning, location, building or arrangement of manufacturing and power plants.

Wallace Lawrence has been appointed superintendent of the Fifty-ninth and Seventy-fourth street power stations of the Interborough Rapid Transit Company, New York City, and Thomas Alkop, formerly in charge of the Fifty-ninth street station of the Interborough company, is now chief at the Waterside station of the New York Edison Company.

William D. Ennis has been appointed professor of mechanical engineering in the Polytechnic Institute of Brooklyn, N. Y. Professor Ennis is a graduate of the Stevens Institute, and from 1901 to 1905 was engineering adviser to various Rockefeller interests, including the American Linseed Company. Since 1905 he has been exclusively engaged on special power investigations for the American Locomotive Company.

Obituary

As we go to press we are grieved to learn of the death, on July 14, of James F. Wilson, who for thirty-two years was superintendent and supervising engineer of the Equitable Life Assurance Society's building, 120 Broadway, New York city, from which position he resigned on March 1 of the present year in consequence of ill health. Mr. Wilson was 60 years of age, a thirty-second degree Mason, member of Joppa lodge, of Brooklyn, N. Y., a member of the Royal Arcanum, and a charter member of Phœnix Association, No. 24, N. A. S. E. He was, perhaps, the best known and most highly respected engineer in New York, and his death will be mourned by a host of friends. The funeral services were held on the evening of July 17, at his late residence, 21 Barnet street, East Orange, N. J. Mr. Wilson is survived by a widow and a married daughter.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Gas-engine Compression and Efficiency

Why does increasing the compression of a gas engine increase its efficiency?

H. Y. W.

Increasing the compression increases the efficiency within certain limits because the rise of pressure due to combustion is greater with high than with low compression, and the mean effective pressure is therefore higher per unit of mixture taken into the cylinder. Under average conditions the pressure rise due to the combustion of the mixture is proportional to the heat units in the mixture divided by its specific heat (at constant volume) and multiplied by the 0.77 power of the compression pressure. With all other conditions unchanged, therefore, the rise of pressure obtained with a compression pressure of 90 pounds would be 1.7 times the rise of pressure obtained with 45 pounds compression.

[The foregoing is a correction of the reply given to the same question last month, in which the *rise* of pressure due to combustion was inadvertently spoken of as the "explosion pressure."—Editors.]

Heating Surface of Vertical Boiler

How is the heating surface of a vertical tubular boiler computed?

C. S. E.

The total heating surface is the sum of the heating surfaces of the tubes, the bottom tube-sheet and the fire-box wall. The heating surface of the tubes is equal to

$$3.1416 \times \textit{tube diam.} \times \textit{tube length} \times \textit{number of tubes} \div 144.$$

The heating surface of the tube-sheet is equal to the gross area of the tube-sheet minus the combined areas of the tube ends, divided by 144.

The heating surface of the fire-box wall is equal to

$$3.1416 \times \textit{box diam.} \times \textit{box hight} \div 144.$$

Representing the various dimensions by symbols as below, the total heating surface is given by the formula:

$$\frac{d\,L\,n + 0.25\,(D^2 - d^2\,n) + D\,h}{45.84} = S,$$

the symbols having the values:

d = Diameter of each tube, in inches,
L = Length of tubes, in inches,
n = Number of tubes,
D = Diameter of fire-box, in inches,
h = Hight of fire-box in inches,
S = Heating surface, in square feet.

Dynamo Brush Contact

What should be the area of brush contact for a 250-volt dynamo, with respect to the current carried?

M. F. P.

The total area of all brush faces in square inches should be not less than one-twentieth of the maximum number of amperes carried by the machine, if the brushes are of fairly hard carbon; if of soft carbon, or graphite, one-fifteenth of the maximum number of amperes is a good value for the total brush-face area in square inches.

Leather-belt Operation

Which side of a leather belt should go next to the pulley, and why?

W. F. D.

The smooth or finished side should go next to the pulley because the actual area of contact is greater than when the rough side is in contact; consequently, the adhesion due to friction is greater. Moreover, the smooth side has less tensile strength than the rough side, so that any wear on that side will weaken the belt less than wear on the other side would.

Cylinder Ratios of Steam Engines

What determines the cylinder ratio of a compound engine?

C. E.

The point of cut-off in the high-pressure cylinder and the total number of expansions desired. For example, suppose the engine is to run condensing, taking steam at 150 pounds absolute pressure and working it down to 10 pounds absolute; this means 15 expansions, total. If the high-pressure valve is to cut off normally at ¼ stroke, and if the clearance in the high-pressure cylinder is to be 3 per cent., there will be

$$\frac{1 + 0.03}{0.25 + 0.03} = 3.68$$

expansions in the high-pressure cylinder. In order to get 15 expansions, total, the steam must expand

$$\frac{15}{3.68} = 4.08$$

times during the stroke of the low-pressure piston; that is to say, the total volume of the low-pressure cylinder, including the clearance, must be 4.08 times as large as the total volume of the high-pressure cylinder, including clearance. If the strokes and clearances are the same in both cylinders, the area of the low-pressure piston will be 4.08 times the area of the high-pressure piston, or $\sqrt{4.08} = 2.02$ times its diameter. On the assumption of equal strokes and clearance percentages, the relation of the low-pressure cylinder to the other factors involved is given by the formula:

$$\sqrt{\frac{d^2\,N(s + c)}{1 + c}} = D,$$

in which

d = Diameter of high-pressure piston,
N = Total number of expansions to be obtained,
s = Point of stroke at which cut-off occurs in the high-pressure cylinder, expressed decimally,
c = Clearance, expressed as a decimal part of the stroke,
D = Diameter of low-pressure piston.

Torque and Pound-feet

What is meant, in referring to electric motors, by "pound-feet of torque?"

T. McM.

The tangential pull at the periphery of the armature, in pounds × feet of radius. Thus, if the torque is 50 pound-feet, the tangential pull will be 50 pounds divided by the radius in feet or parts of a foot; if the diameter of the armature is 18 inches, the radius will be 9 inches, or three-fourths of a foot, and the tangential pull at the periphery will be $50 \div 0.75 = 66.67$ pounds. In other words, torque in pound-feet = pull in pounds × radius in feet, or pull in pounds at one foot radius.

Increasing the Power of a Gas Engine

Can the power of a gas engine be increased by increasing the compression and using electric ignition instead of a hot tube?

F. Mfg. Co.

If the compression is not high, increasing it will probably increase the power of the engine. If the engine runs on natural or illuminating gas, its compression can be carried up to 90 pounds advantageously; if on producer gas, 130 to 150 pounds may be used, according to the efficiency of the cooling arrangements. But before increasing compression you should be sure that the connecting-rod and crank-shaft will stand the heavier explosions. Better have an expert diagnose the case. Electric ignition is usually more effective than a hot tube.

Pressure per Square Inch on Dynamo Bearings

Knowing the output and efficiency of a dynamo and the size and speed of its pulley, how is the pressure per square inch on the bearing figured?

L. A. F.

Boiled down to a single formula:

$$\frac{44{,}220 \times K.W.}{e \times S \times D \times L} = p,$$

in which

$K.W.$ = Dynamo output in kilowatts,
e = Dynamo efficiency expressed as a fraction,
S = Belt speed in feet per minute = 0.2618 × r.p.m. × pulley diameter in inches,
D = Diameter of bearing in inches,
L = Length of bearing in inches.

The formula is derived as follows:

Output in kilowatts divided by 0.746 = horse-power; multiplying this by 33,000 gives foot-pounds per minute. Hence, 44,220 × $K.W.$ = output in foot-pounds per minute. Dividing this by the dynamo efficiency gives the foot-pounds per minute delivered by the belt; again dividing by belt speed gives pull in pounds by the belt, and finally dividing by the projected area (diameter × length) of the bearing gives the pull in pounds per square inch of bearing area. This assumes that the belt is slack enough to give no pull on the side approaching the pulley.

Book Reviews

THE WALSCHAERT LOCOMOTIVE VALVE-GEAR. By W. W. Wood. Published by the Norman W. Henley Publishing Company, New York. Cloth; 193 pages, 5¼x7½ inches; illustrated. Price, $1.50.

This book is composed of four general divisions. The first divison comprises an analysis of the Walschaert valve gear; the second treats of designing and erecting; the third points to the advantages claimed for this gear, and the fourth division is made up of questions and answers relative to it. Attention is particularly called to the second division, where are found two diagrams, on folding sheets, that show the position of the valve, link and all other parts of the gear, when the main crank-pin is at nine different points in its revolution; both with the outside admission D-slide valve and the piston valve of inside admission. Separate cardboard models of these two valves, to be used in connection with the diagrams, are contained in a pocket in the cover.

THE STEEL SQUARE AS A CALCULATING MACHINE. By Albert Fair. Published by the Industrial Publication Company, New York. Cloth; 81 pages, 5x7 inches, illustrated. Price, 50 cents.

This little book gives simple directions, in every-day language, for using the common steel square for the solution of calculations that often come up in the work of mechanics, and engineers, even. It is surprising how quickly complicated problems can be worked out by this means, as explained by the author. The illustrations are numerous, and the absence of confusing "higher mathematics" is commendable.

MODERN POLYPHASE MACHINERY. By Andrew Stewart. D. Van Nostrand Company, New York. Cloth; 296 pages, 5x7 inches; 181 illustrations; price, $2.

In this book the author has attempted to give an exposition of the principles and construction of polyphase generators, motors and converters. He evidently knows his subject well enough, but between slipshod typography and fourth-rate engravings his well-meant efforts are severely handicapped. He explains briefly the generation of alternating currents, the magnetic properties of iron and steel, the characteristics of insulating materials, the design and construction of machines, parallel operation, motor speed control and the testing of generators and motors. One chapter, also, is devoted to turbine alternators and another to a description of represntative types of European polyphase generators.

QUESTIONS AND ANSWERS FROM "THE GAS ENGINE." Published by *The Gas Engine* Publishing Company, Cincinnati, Ohio. Cloth; 274 pages, 5x7 inches. Price, $1.50.

As the title indicates, this is a compilation of questions and answers which were printed originally in *The Gas Engine*, and it is regrettable that a little editing was not added to the process of compilation. There is a good deal of very useful information in the book, but there are some errors, much slovenly diction, and many misprints. In several places the answers are inadequate and some answers are inconsistent with others. These deficiencies, of course, detract greatly from the value of the book. To anyone who is sufficiently well versed in gas-engine principles to discriminate between the wheat and the chaff, the book will be useful for reference.

LOCOMOTIVES: SIMPLE, COMPOUND AND ELECTRIC. By H. C. Reagan. Published by John Wiley & Sons, New York; London, Chapman & Hall, Limited. Fifth edition, revised and enlarged. Cloth; 946 pages, 5½x8½ inches, illustrated. Price advanced from $2.50 to $3.50.

This edition embraces the latest developments of steam and electric locomotives. The new chapters on the steam engine include treatments of the balanced four-cylinder compound type, and the steam superheater. Regarding the electric locomotive, the principles of the apparatus and methods of application are explained. To a lay mind it appears that the author has made the most of the best material available, access having been had to manufacturers' and technical publishers' data, and to those who are interested in the subject the book can be apparently unqualifiedly recommended.

THE TREATMENT OF STORAGE BATTERIES. By R. W. Vicarey. Published by The Commercial Electro-Chemical Analysis Company, Ltd., London, England. Paper; 62 pages, 8½x11 inches; 32 illustrations. Price, 2s. 6d.

This is a most instructive and useful little publication, based on the practical experience of the author in handling various types of accumulator industrially. Beginning with the selection of a battery room, he takes the reader through a course including tests, the operation of charging, connecting up cells, troubles and their remedies, varying rates of discharge, and the maintenance of proper specific gravity. The book closes with a glossary of terms peculiar to storage battery work. It is a pity the pages were not made of one-half the present area and the binding of limp leather; the book is too useful to be put up in such unpractical size and protected only by paper covers.

THE TWENTIETH CENTURY TOOLSMITH AND STEELWORKER. By H. Holford. Published by Frederick J. Drake & Co., Chicago. Cloth; 240 + pages, 5x7½ inches, illustrated. Price, $1.50.

This book was written more especially in the interests of blacksmiths, toolmakers and mechanics who have to do with the use, repair and manufacture of steel tools. The information is presented in a simple way that the average mechanic will readily understand, affording an easily acquired knowledge of the art of working steel which must be of benefit to all who read, and especially to young mechanics and apprentices. Beginning with the nature of steel and the necessity for it, the work embraces a series of practical treatments and processes, concluding with a number of useful formulas.

HENLEY'S TWENTIETH CENTURY BOOK OF RECIPES, FORMULAS AND PROCESSES. Edited by Gardner D. Hiscox, M. E. Published by the Norman W. Henley Publishing Company, New York. Cloth; 787 + pages, 6x9 inches, illustrated. Price, $3.

This work is a sort of cyclopedia containing "nearly ten thousand scientific, chemical, technical and household recipes, formulas and processes for use in the laboratory, the office, the workshop and in the home." It was compiled to meet *practical* requirements, the editor taking pains to secure verification of the subject matter, and avoid everything of questionable merit. While a great many old recipes are contained in the book, there are a great many new ones, bringing it up to date. The main subjects are arranged in alphabetical order, with subdivisions to cover analogous topics, precisely as in an encyclopedia. The type and illustrations are very clear, and altogether it is a valuable compendium to have.

Books Received

"The Engineering Index Annual." Year 1906. The *Engineering Magazine*, New York. Cloth; 412 pages, 6¼x9¼ inches. Price, $2.

"Standard Examination Questions and Answers for Locomotive Firemen." By W. G. Wallace. Frederick J. Drake & Co., Chicago, Ill. Flexible leather; 343 pages, 4¼x6¾ inches; illustrated; indexed. Price, $2.

"Handbook on Engineering." By Henry G. Tulley. Henry C. Tulley Co., St. Louis, Mo. Leather; 1072 pages, 4½ x6½ inches; 476 illustrations; indexed. Price, $3.50.

"Denatured or Industrial Alcohol." By Rufus Frost Herrick. John Wiley & Sons, New York. Cloth; 516 pages, 5¾ x9¼ inches; tables; 163 illustrations; indexed. Price, $4.

The Civil Service Commission Withdraws Technical Diploma Qualification

The Civil Service Commission some time ago announced an examination to fill a vacancy in the position of chief engineer of the United States Court House and Post Office building at Chicago and restricted the application to graduates from recognized institutes of technology. It was forcibly represented by the engineering societies and press that it was the commissioners' business to determine whether a man was qualified for the position, not how he came to be so. The announcement was withdrawn, and has been reissued in the following form:

It is desired to secure the services of a person not only qualified to administer the local engineering affairs of the building named, but competent also to act as consulting engineer on questions which may arise in regard to the mechanical and electrical equipment of public buildings in the city of Chicago and in the territory contiguous thereto, and who will be able to prepare plans and specifications and supervise the execution of engineering work of a general character.

The examination will consist of the subjects mentioned below, weighted as indicated:

Subjects.	*Weights.*
1. Engineering report writing (on a subject to be furnished in the examination room)	15
2. Mechanism, applied mechanics, and the strength of materials as covered in elementary treatises on these subjects	10
3. Thermodynamics of the steam engine and theory and practice of steam machinery, including boilers, engines, pumps, etc.	10
4. Electrical engineering, including fundamental principles of electricity, dynamo electrical machinery, instruments and measurement, and the theory and practice of the generation, transmission, and distribution of electric current and its application in lighting and power service	15
5. General engineering, including simple questions of a practical nature on hydraulics, flow of steam and other fluids, heating and ventilating of buildings, plumbing and sanitary work, chemistry of the combustion of fuels, etc.	15
6. Practical experience	35
Total	100

No applicant who has not had at least five years' experience in engineering work similar to that required in this position will be admitted to the examination. Technical education will, however, be given due weight as a part of the required five years of practical experience.

Business Items

The New York office of A. L. Ide & Sons has been removed from 11 Broadway to 90 West street.

The William Powell Company, of Cincinnati, O., has opened a branch office at room 301, 90 Liberty street, New York, with A. H. Hecker, manager.

In order to take better care of its growing trade in Montana, the Minneapolis Steel and Machinery Company has recently opened an office at 352 Phœnix building, Butte, Montana, under the management of J. E. Lanning.

A contract has been let to Muralt & Company, engineers, of 114 Liberty street, New York, for a complete municipal electric light plant for the town of Franklin, La. The power house will contain Heine safety boilers, Harrisburg engines and Fort Wayne Electric apparatus.

The Strong, Carlisle & Hammond Company, 342 Frankfort street, Cleveland, O., is issuing an eight-page instruction book on the Squires feed-water regulator. The regulator is illustrated in parts and assembled, its principle of operation is thoroughly described and detailed instructions are given for its placing and operation.

R. E. Fox, Jr., has resigned the management of the New York office of the Platt Iron Works Company, to become secretary and manager of the sales department of the Engineering Company, 111 Broadway, New York. This company manufactures and installs the balanced-draft system of furnace regulation.

Oscar Winter, for more than six years steam and engine expert of the National Tube Company, formerly the Lorain Steel Company, of Lorain, O., has severed his connection with that company and opened a consulting office in the Rockefeller building, Cleveland, where he will give special attention to expert work in steam engineering.

In order to handle its business in electric generators and motors in southern Ohio, the Cleveland office of the Crocker-Wheeler Company, of Ampere, N. J., has found it advisable to open a sub-office in the Columbus Savings and Trust Company building, Columbus, O. The sub-office will be in charge of Charles W. Cross, formerly of the Cleveland office.

The Terry Steam Turbine Company, Hartford, Conn., has secured the order for eight 300-horse-power steam turbines for the new Waterside plant of the New York Edison Company. These turbines are to be used direct-connected to centrifugal pumps and are for boiler-feed purposes. The capacity of each turbine pump unit will be 1000 gallons per minute, against a pressure of 300 pounds.

The Northern Engineering Works, crane builder, Detroit, Mich, reports recent shipments of cranes for power station service as follows: A 24-ton capacity and 62-foot span crane for the Buffalo & Susquehanna Coal Mining Company, at Sagamore, Penn.; a 6-ton capacity and 36-foot span crane for the Winchester & Washington City Railway, and a 5-ton capacity by 36-foot span crane for the Watertown Electric Light Company.

P. A. Moulton, 92 Liberty street, New York city, is now the New York representative of the Baum steam and oil separators, manufactured by the Hershey Foundry and Machine Company. He is also representing Hicks & Timberlake, of St. Louis, Mo., for their ball-bearing glands, gage glasses, ice machines, etc. On account of the increased lines now carried, Mr. Moulton has taken new offices with larger space at his old address, as given above.

The General Electric Company furnished the electrical equipment for a factory addition, just completed, to the works of the Willamette Pulp and Paper Company, of Oregon City, Ore. The new equipment consists of a 600-kilowatt 3-phase 600-volt revolving-field alternating-current generator direct-connected to a 1000-horse-power waterwheel built by the Platt Iron Works Company; two 200-horse-power, one 100-horse-power and one 50-horse-power induction motors, and a 10-horse-power elevator motor.

A booklet concisely summarizing what a Cochrane feed-water heater is and what it does is being distributed by the Harrison Safety Boiler Works, of Philadelphia. It shows that the Cochrane open feed-water heater will in many plants save about 16 per cent. of the coal bill, one-sixth of the water bill, improve the quality of the boiler-feed supply, increase the capacity of the boilers by one-sixth, and supply hot water, not only for boiler feeding, but also for other purposes about industrial plants, as washing, dyeing, etc. The Cochrane oil separators are also described and illustrated.

The Vanda Company, 96 Spring street, New York, has recently doubled the capacity of its factory, and now enters the field with a piston- and valve-rod packing. This new packing is said to be constructed on different lines from other piston packings on the market and strong claims are made for its self-lubricating qualities. In order to better market this packing and to have as many distributing depots as posible throughout the country, the company has made arrangements with the H. W. Johns-Manville Company, by which that company will act as co-distributor for all articles manufactured by the Vanda Company.

The New York State Steel Company, of Buffalo, N. Y., after a thorough trial of a 4000-horse-power We-Fu-Go water softening and purifying system, manufactured by Wm. B. Scaife & Sons Company, of Pittsburg, Penn., has placed an order for another 4000-horse-power system to be added to the present system, making a total of 8000 horse-power. The large number of orders received by Wm. B. Scaife & Sons Company for water softening and purifying systems is evidence of the increased interest being displayed by steam users and manufacturers in overcoming the many expenses and annoyances connected with the use of hard or dirty water.

The recent cry of "dull times," raised by various manufacturing interests of the country, finds no echo in the business of Allis-Chalmers Company, which continues to show a steady gain. During the month of May this company shipped from its works 553 cars of machinery, which was a gain of 20 cars over the record established for April. In April the aggregate weight of shipments was 21,680,847 pounds, while for the month of May the figure had risen to 23,772,242 pounds, making a total weight for the two months of 45,463,089 pounds. Cars bearing this enormous quantity of machinery, if coupled in one train, would have covered a distance of about eight miles.

The Salamander Grate Bar Company, 126 Liberty street, New York, reports that it is very busy on all types of its grates, of which it makes more than 20 styles. It is especially busy filling orders for the Aetna shaking, Salamander dumping and Rogers stationary grates. The company has just received two orders from large concerns in Kentucky for Aetna shaking grates, one for a furnace 12 feet 6 inches wide and 5 feet long, the other for a furnace 10 feet 6 inches wide, and 5 feet 6 inches long. One of these orders is for a plant where Aetna grates have been in use since 1902 with no repairs, and

when additional boilers were ordered this grate was also ordered for them.

Several mechanical-draft plants of extraordinary size are described in a booklet recently published by the Green Fuel Economizer Company, of Matteawan, N. Y. A pair of fans supplied to the East St. Louis & Suburban Railway are said to be the largest ever built with overhung wheels, the wheels measuring 19 feet and 6 inches in diameter, by 7 feet wide at the tips of the blades and being driven by Corliss engines. Photographs are shown of nearly a dozen other large plants and also drawings and layouts of a number of large and interesting installations, including the new Hoboken terminal of the Lackawanna Railroad. A portion of the book is devoted to the Green fuel economizer.

Richard Thompson & Company, 128 Liberty street, New York, are making a specialty of installing steam plants with forced draft, in connection with their special fine-fuel dumping grate and damper regulator. The regulator operates the damper, or dampers, and balanced valve for either turbine or fan engine together. Among the plants recently installed with this system are the St. Regis hotel and the new Knickerbocker hotel, New York. In the latter, the furnaces are 12 feet 7 inches wide by 7 feet deep. The firm has also installed grate bars under the new boilers of the Tribune building, 12½ feet wide by 7 feet deep, and in the new Singer, forty-one-story building, where the furnaces are 9 feet square.

Some recent changes have been made in the personnel as well as in the addresses of the offices of the American Stoker Company. The company's offices are as follows: General offices, Erie, Penn., M. E. Ellis, sales manager; Salt Lake City, Dooly Block, C. P. Overfield, manager; Chicago, 66 Fisher Building, Thomas M. Yoder, manager; St. Louis, 1012 Chemical Building, G. A. Wells, manager; Cincinnati, 315 Fourth National Bank Building, F. M. Cronkrite, manager; Boston, 176 Federal street, G. H. Moseman, manager. A Pittsburg office was opened in July under the management of H. C. Adam. Those desiring information and data relating to American underfeed stokers, American chain grates or American forge or industrial furnace stokers are invited to address the nearest branch office.

As the outcome of the recent fly-wheel explosion at the Hotel Knickerbocker, New York city, which was due to the engine "running away," the hotel management is installing four complete "Monarch" engine-stop systems, made by the Consolidated Engine Stop Company, 130 to 134 East Twelfth street, New York. As stated in POWER, at the time of the accident there was no engine-stop system employed; and the hotel people have come to the conclusion that it would be wiser to prevent "runaways" in the future by installing safety stops. The Consolidated company has also received orders for four "Monarch" systems for the Hotel Plaza, and three for the Apthorp apartment hotel, also in New York city, besides orders for several engine-stops for the Procter & Gamble Company's plant at Ivorydale, Ohio, Kansas City and Staten Island.

The Edge Moor Iron Company, Edge Moor, Del., has received a contract to furnish the Edge Moor boilers to be installed in the 24 oil pumping plants which will be erected by the Southern Pacific Company, to pump oil from the San Joaquin Valley, California, to the sea. This pipe line will be 285 miles long. The boilers will be installed in three units in each plant, each boiler having a capacity of 250 horse-power. The George E. Dow Pumping Engine Company, of San Francisco, has secured the contract for the entire installation, and the Tracy Engineering Company, of Los Angeles and San Francisco, which is the western agent for the Edge Moor Iron Company, will erect the boilers in the various plants, which are spaced 12 miles apart. It is stated that this is the largest water-tube boiler installation in the country for furnishing steam for pumps pumping oil.

It is stated that the largest single order for gas engines ever placed in this country, and for the largest engine of this type ever built, has recently been awarded by the United States Steel Corporation to Allis-Chalmers Company, Milwaukee, Wis. Within the past year this company has taken orders for 36 gas engines of four thousand horsepower each, or an aggregate of 144,000 horsepower, 25 of which are to be installed as a part of the mammoth new plant now in course of construction by the steel corporation at Gary, Ind.; seven for the Homestead plant of the Carnegie Steel Company, and four in the South Chicago works of the Illinois Steel Company. These large gas engines weigh 1,500,000 pounds apiece. Their great size is also demonstrated by the fact that the shaft of each measures three feet in diameter. It will require 2300 cars to transport these machines from the works of the Milwaukee company to the different plants of the steel corporation, where they will be installed.

The new power plant of the Pacific Mills, Lawrence, Mass., will contain three Allis-Chalmers steam turbines operating condensing at 1800 revolutions per minute, direct-connected to three-phase, 60-cycle, alternating-current generators, of the same company's design and build, which have a rated capacity of 3300 horse-power, in addition to which there will be a 75-kilowatt Allis-Chalmers engine-driven generator with belted exciter, for night lighting, two other Allis-Chalmers exciters for the main generating units, and various auxiliary apparatus. The steam generating equipment consists of twelve 72-inch boilers, each with 20-foot tubes, built by the Bigelow Company, of New Haven, Conn. These are to be installed in batteries of four. Steam will be supplied to the turbines at 150 pounds pressure and superheated 125 degrees Fahrenheit by Foster superheaters. Natural draft will be provided for the furnaces through a stack 9½ feet in diameter and 200 feet in hight. No forced draft will be needed. When the plant is finally extended to the full capacity of 10,000 horse-power, which it has been laid out for, another large chimney will be erected on foundations already built.

New Equipment

The Corydon (Ind.) Light, Water and Ice Company will install a new engine and dynamo this fall.

The Weston Engineering Company, 39 Wall street, New York, want catalogs of smoke-consuming devices.

The H. B. Smith Company, Westfield, Mass., manufacturing steam heating apparatus, will enlarge its plant.

The power plant of the Huntsville (Ala.) Railway, Light and Power Company will be doubled at a cost of about $35,000.

The citizens of Frederick, Okla., are reported to have voted to issue $10,000 water extension and $25,000 sewer bonds.

The Sandusky (Ohio) Gas and Electric Company is contemplating installing a 120-kilowatt alternating-current generator.

The Duncan (I. T.) Light and Power Company is contemplating the installation of a 75-kilowatt alternator and an ice plant.

J. J. Wheeler, Friends University, North Hall, Wichita, Kan., will like to receive catalogs of steam engines and air compressors.

Plans are being prepared for an electric light plant, to cost about $15,000, at University Place, Neb. R. E. Shelley is city clerk.

The plant of the Kinsley (Kan.) Electric Light and Power Company has been taken over by A. D. Coleman and Albert L. Moe, Albuquerque.

The city of Bradentown, Fla., has voted the issuance of $20,000 bonds for street paving, $15,000 for sewer systems and $10,000 for water works.

The Sparta (Ga.) Cotton Mills has been organized with a capital stock of $100,000 to build cotton factory. W. T. Bryan, Athens, Ga., is president.

The Broad River Power Company has been incorporated at Elberton, Ga., with a capital stock of $250,000. A. S. J. Stovall, E. B. Tate, etc., incorporators.

The Baltimore & Ohio Railroad Company has requested permission to erect a forced-draft station in connection with its electric power plant at Baltimore.

The Southern Traction and Power Company, Pine Bluff, Ark., has secured franchise to construct electric light plant and water works at Russellville, Ark.

The Meridian (Miss.) Light and Railway Company is planning extensive additions and improvements, which will involve an expenditure of about $60,000.

The Virginia Passenger and Power Company, Petersburg, Va., will install new arc lights and make improvements to its power plant, expending about $50,000.

Plans and specifications for improvements to the electric-light plant at Franklin, La., are being prepared. These will cost about $20,000. J. C. Lewis is mayor.

The Redlands (Cal.) Central Railway Company has been organized to build an electric railway. Capital, $1,000,000. Directors, J. H. Fisher, O. T. Higgins, etc.

The Wagner, Lake Shore & Armour Traction Company has been incorporated to construct an electric railway from Wagner, S. D., to Mitchell; capital $1,000,000. Incorporators, A. H. Pease, John Absher, of Wagner and others.

The American River Electric Company, of San Francisco, is making preparaions to construct an auxiliary electric plant on Stockton Channel to cost $250,000. B. C. Condit, 320 East Weber avenue, Stockton, Cal., is superintendent.

New Catalogs

Jackson Flue Scraper Company, Jackson, Mich. Circular. Spiral flue scraper. Illustrated.

Turner Oil Filter Company, Niles, Mich. Booklet. Oil filters. Illustrated, 18 pages, 3½x6 inches.

Du Bois Iron Works, Du Bois, Penn. Catalog. Steam and power pumps. Illustrated, 32 pages, 6x9 inches.

The Amsler Engineering Company, Pittsburg, Penn. Catalog. Gas producer. Illustrated, 20 pages, 6½x8 inches.

Ohio Brass Company, Mansfield, Ohio. Catalog No. 7. Electric railway and mine supplies. Illustrated, 582 pages, 6x9 inches.

Hicks & Timberlake, 3019 North Broadway, St. Louis, Mo. Catalog. Hicks ball bearing gland. Illustrated, 8 pages, 3½x6 inches.

James L. Taylor Manufacturing Company, Bloomfield, N. J. Catalog No. 8. Screw clamps. Illustrated, 24 pages, 3½x6 inhes.

American Spiral Pipe Works, P. O. Box

485, Chicago, Ill. Catalog. Forged steel pipe flanges. Illustrated, 94 pages, 8x10 inches.

Curtis & Curtis Company, Bridgeport, Conn. Catalog. Pipe cutting and threading machinery. Illustrated, 38 pages, 7x10 inches.

The Loew Manufacturing Company, Cleveland, Ohio. Booklet. Pipe threading machinery. Illustrated, 16 pages, 3½x6 inches.

C. W. Hunt Company, West New Brighton, S. I. Catalog No. 072. Coal handling machinery. Illustrated, 63 pages, 6½x9 inches.

Jacobson Machine Company, Warren, Penn. A practical treatise on the gas and gasolene inches. Illustrated, 108 pages, 4x6½ inches.

The United States Metallic Packing Company, Philadelphia, Penn. Catalog. Metallic packings. Illustrated, 14 pages, 3½x6 inches.

B. F. Sturtevant Company, Hyde Park, Mass. Bulletin No. 125. Class VS 5 vertical engines. Illustrated, 8 pages, 6x9 inches.

D. & W. Fuse Company, Providence, R. I. Catalog No. 12. Cartridge fuses and cutouts. Illustrated, 88 inches, 5½x8½ inches.

Green Fuel Economizer Company, Matteawan, N. Y. Catalog. Fans, blowers, exhausters. Illustrated, 96 pages, 6x9 inches.

Kerr Turbine Company, Wellsville, N. Y. Bulletin No. 2. Steam turbine, gas, forge and cupola blowers. Illustrated, 16 pages, 6x9 inches.

Standard Gage Manufacturing Company, Syracuse, N. Y. Pamphlet. Eclipse oil filters, exhaust heads. Illustrated, 3½x6 inches.

Franklin Filter Company, 208 North Commercial street, St. Louis, Mo. Pamphet. Efficient Bearings. Illustrated, 16 pages, 6x9 inches.

Niles-Bement-Pond Company, 111 Broadway, New York. List No. 13. Second-hand metal-working machinery. 51 pages, 4½x7 inches.

Julian D'Este Company, 24 Canal street, Boston, Mass. Catalog. Curtis engineering specialties. Illustrated, 32 pages, 3½x6 inches.

Simonds Heating and Specialty Co., Detroit, Mich. Pamphlet. Modern Methods of Steam Heating. Illustrated, 32 pages, 6x9 inches.

The New York Safety Steam Power Company, 114 Liberty street, New York. Catalog. Dock gas engine. Illustrated, 16 pages, 6x9 inches.

Jacobson Machine Manufacturing Company, Warren, Penn. Bulletin C. Gas and gasolene engines. Illustrated, 16 pages, 6x9 inches.

Locke Regulator Company, Salem, Mass. Catalog. Regulators, valves, steam separators, traps. Illustrated, 54 pages, 5x9 inches.

Goldschmidt Thermit Company, 43 Exchange Place, New York. Pamphlet. Thermit rail joint. Illustrated, 5 pages, 4x9 inches.

The D. T. Williams Valve Company, Cincinati, O. Catalog. Brass and iron valves, gage-cocks, fittings, lubricators, steam traps, separators, etc. Illustrated, 164 pages, 5x7 inches.

Help Wanted

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

WANTED—A competent engineer; one able to take care of details heat, light and power end of business; some knowledge of application of compressed air advisable. Address "Canada," Box 260, POWER.

EXPERIENCED mechanical draftsman wanted for steam engineering by firm manufacturing specialty; good opportunity for right man to work his way up; state lowest salary to commence and full particulars. Box 261, POWER.

WANTED—A man with experience in the sale of engines and engine specialties, preferably one that has had shop experience and understands how to indicate engines, set valves, etc.; for further information address Box F, Hudson, N. Y.

WANTED—Technical college graduate as instructor in mechanical engineering, with at least 2 years' drafting-room experience, and a good scholastic record in the principles of mechanics; part of duty to assist in summer term work; state minimum salary that would be accepted; send application and references to Professor of Mechanical Engineering, 357 Market St., Bethlehem, Pa.

WANTED—A young man of practical experience and technical attainments to direct and advise as to all matters appertaining to the production and distribution of steam, electric, air power; heat and light, in a large plant using 11,000 H. P.; the results desired are reliable and high efficiency at minimum cost, from present equipment; a good situation, good opportunities and good compensation for the right man. Box 259, POWER.

WANTED—First-class up-to-date chief engineer; young man with technical knowledge preferred; for large saw mill plant in healthy town in South; must be capable of installing and superintending the operation of entire steam, electric and ice plant and water works system, and be thoroughly trustworthy and of good habits; in replying give recommendations, salary expected and how soon you could report; good position for the right man. Address Box 265, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

MECHANICAL engineer and draftsman with 5 years' experience in boilers, steam turbines, water turbines and governors, as well as shop experience, wishes position. Box 266, POWER.

MANUFACTURER'S agent; power plant equipment manufacturers desiring Chicago representation, on commission or salary and commission basis, kindly address Box 262, POWER.

DRAFTSMAN and mechanical engineer fully familiar with design of gas and refrigerating machinery is open for immediate engagement; 7 years' experience; $100; references. Box 258, POWER.

WANTED — Position as master mechanic for coal mines; experienced in up-to-date mining, compressed air and electric haulage, mining machines, etc.; 28 years old, single; will go anywhere; prefer warm climate; can speak Spanish. Box 255, POWER.

WANTED—Situation by a steam-engine expert, young man; have my own indicators and calorimeters; can make all tests for efficiency; am familiar with turbines and all makes of electrical machinery; am employed at present, but desire to change. Address "Calorimeter," Box 263, POWER.

AN AMERICAN engineer, graduate of Stevens Institute, retained as consultant to two large corporations in London, England, where he has resided the past ten years, is at present in New York, and desires to utilize his spare time abroad, by introducing American mechanical and electrical specialties in Europe; also to undertake expert resident supervision and inquiry. Ample references will be given. Address Gilbert Rosenbusch, Room 504, 17 Battery Place, New York.

WANTED—Position as chief engineer or master mechanic of plant or superintendent of repair shop; competent to install, operate and repair steam, electric, refrigerating, and hydraulic machinery; would take entire charge of mechanical part of plant and guarantee results; experience, four years' apprenticeship machinist trade, 11 years engineer at sea, locomotive and marine repair, sugar mill and blast furnace work; hold United States license chief engineer ocean steamers, unlimited tonnage; references; age 32; would accept position in any part United States, Canada, Mexico, Central or South America. Box 264, POWER.

Miscellaneous

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

IF YOU DESIRE to learn the latest improvement in steam boilers, correspond with the Detroit Water Tube Boiler Co. See their advertisement on page 166.

ENGINES AND BOILERS, ⅛ to 2 h.p. engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make free examination and report if patent can be had, and exact cost.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass avenue, St. Louis, Mo.

For Sale

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

FOR SALE—Cyclopedia of electricity; five volumes, three-quarters red morocco, leather binding; books are in fine condition; used but short time; cost $19; will sell for $9. Address "R. S. M.," POWER.

FOR SALE—A slightly used engineering library. Steam, electrical, mechanical. Twelve volumes bound in three-quarters red morocco leather. Cost new $60. Will sell for $18. Address "R. L. N.," POWER.

FOR SALE—Cyclopedia of engineering; steam, electrical, mechanical; bound in three-quarters morocco; four volumes; cost new $19; are in fine condition; will sell for $9. Address "M. B. T.," POWER.

HYDRAULIC ACCUMULATOR for sale, measurement 36-9-72, water weighed, running pressure 1500 lbs. to the square inch; never used; just as come from manufacturer. Write Winslow Bros. & Smith Co., Norwood, Mass.

FOR SALE—Two 25 kw. direct current 110 volt Crocker-Wheeler generators direct connected to De Laval steam turbines suitable for 125 to 150 pounds steam pressure condensing or non condensing; also one 2200 gallon centrifugal pump direct connected to De Laval steam turbine; this is new machinery. Address The National Cash Register Company, Dayton, Ohio.

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Physical Properties of Saturated Steam

The Steam Tables Explained; Why Temperature Varies with the Pressure and What Is Meant by Latent Heat, Saturated Steam, etc.

BY FRED R. LOW

In all engineers' handbooks and in many catalogs designed to interest engineers there are tables of the "Physical Properties of Steam," giving the temperature of steam at given pressures, the amount of heat required to make a pound of it, the relative and specific volumes, etc. I want in this lecture to get at not only a working knowledge of such a table, but to study out a little why the temperature should vary with the pressure, what is meant by sensible and latent heat, "dry saturated steam" and the various quantities of which the table treats.

The changes which we are going to trace in the physical properties of steam are the results of the application or withdrawal of heat, and if we can get a proper conception of the nature of heat, our task will be two-thirds completed. Since heat is but a form of energy, let us commence by recalling that energy occurs in two forms which are called "potential" and "kinetic" energy.

In Fig. 1, suppose we have a piston in a cylinder connected to a stand-pipe. When the piston moves out and the cylinder fills with water, the column in the stand-pipe is lowered. The effect is the same, as you will see by comparing Fig. 2, as though a block of water of the capacity of the cylinder had been taken from the top of the column and lowered to the level of the cylinder. Each pound of this water would give up a foot-pound of energy for every foot that it fell, and this energy would be expended in overcoming the friction of the water itself and of the piston, and in doing such work as might be taken from the piston in some such manner as I have roughly indicated in the sketch. The sum of all these energies would be just enough to restore the water to its original elevated position.

The block of water, when it was at the top of the column, was no different in appearance from another similar block of the water farther down. It looked no different, felt no different, weighed no more; and yet it had in it, due to its elevated position, due to its greater distance from the center of the earth which was attracting it, the property, the potentiality, of doing work. There exists between this water and the earth an attraction which is called the attraction of gravitation. It takes energy to separate the earth and the water against the action of this force, and when they come together again this energy is released and made available. In the meantime it is stored, latent, potential in the elevated weight. The energy which is thus absorbed by or stored in a body or system of bodies by reason of their separation against a mutual attraction is called "potential energy."

In Fig. 3 a block of water falls, in effect, from the top of the column to the same level as before, but in this case the energy released, instead of acting upon a piston, is made to act upon the mass of the water itself and to deliver it in a rapidly moving jet. This jet may be made to impinge upon a wheel which absorbs its energy by bringing the water to rest and taking up its motion itself against the resistance of whatever mechanism may be attached. In this case, also, the energy represented by the friction of the water and that of the wheel, and the work accomplished by the latter, together with the energy represented by any velocity which the wheel fails to take out of the water, will be sufficient to elevate the water through the hight indicated on the diagram, from the center of the jet to the center of gravity of the block in its elevated position.

But in this case the water issuing from the jet is different from the rest of the water in that it is imbued with motion. It looks different and feels different. One cannot see the potential energy in the stationary block at the top of the column, but he can see the energy in this rapidly moving jet; or if he cannot see the energy he can see that it is there. The top of the column feels like any other water, but a jet issuing from a high-pressure hydraulic service will cut one like a bullet from a rifle.

This energy absorbed by a mass in acquiring motion, in overcoming its inertia, is called "kinetic" energy.

Imagine a weight attached to an elastic cord and revolved as in Fig. 4. It will extend the cord until the pull of the latter balances the centrifugal force due to its velocity, and continue to revolve in a circle of that radius. If we increase the velocity of the ball, the centrifugal force will be increased, the elastic cord will be extended, the ball will travel in a larger circle and at a greater velocity.

Of the energy applied to effect the change, a portion would go to lifting the ball out farther from the center of attraction against the pull of the elastic cord, to giving it an increase of potential energy, of energy of position, like lifting the weight away from the center of the earth. The remainder only would be available for the production of the increased velocity. This latter portion of

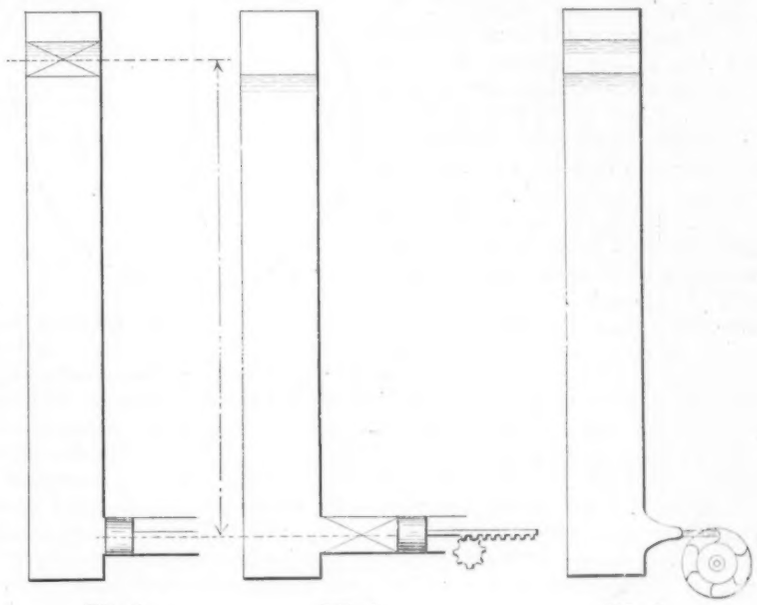


FIG. 1 FIG. 2 FIG. 3

the energy only would be sensible to the touch. The increased velocity would make a very sensible difference in the "feel" of the ball if it should hit one, while, if the rate of travel were the same, it would make no difference in the feel whether the ball were traveling in a two-foot or a ten-foot circle. We might therefore reasonably refer to the energy of motion, the kinetic energy, as "sensible" energy, and to the potential energy, or energy of position, as "latent" energy—energy stored or latent in the body, unapparent to the senses except by considering its relative position but capable of being made manifest when it is permitted to yield to the attraction acting upon it.

Atoms and Molecules Explained

You know that matter is made up of atoms separated from each other by distances which are very great as compared with their diameters. Sir William Thompson says that if a globe of water, or glass, the size of a football (or say 16 centimeters, about 6¼ inches, in diameter) were magnified to the size of the earth and each of its constituent molecules was magnified in the same proportion, the magnified structure would be more coarse-grained than a heap of small shot, but probably less coarse-grained than a heap of footballs. These atoms and molecules, the molecules being combinations of atoms, are held to each other by the same force of universal gravitation that holds the moon to the earth, the earth to the sun and the stars in their relative positions, and revolve about each other at distances determined by the relation of the attractive force and of the centrifugal force due to their motion. If the attractive force is so much stronger than the centrifugal force that the molecules are held in fixed paths, as are the members of our solar system, the body remains solid. You cannot change its shape without overcoming the strong attraction of its molecules for each other. Remember that when you are pulling a bar of iron apart you are not separating a solid homogeneous mass, but simply overcoming the attraction of molecules already separated by distances many times their own diameters. When you remember that it takes a pull of some 50,000 or 60,000 pounds to part a bar one square inch in section, you can get an idea of the magnitude of this attraction; and when you consider that it is practically impossible to press the surfaces together again so closely that the molecular cohesion will be re-established and the bar made whole, you can realize how small is the distance through which the force is effective.

When matter is heated it simply means that in some way or other, by the application of fire, by the passage of a current of electricity or by the blows of a hammer, energy has been imparted to these whirling atoms. Their momentum and their velocity have been increased. They swing in wider circles or ellipses, as is evidenced by the body as a whole expanding, and the impact of its surface molecules, which we recognize as temperature by the sense of touch, is intensified. But still the attraction between the molecules is so much stronger than the centrifugal force due to their velocity that the body remains solid. It is hard to bend, because, in bending it, one side will be stretched and the other compressed. The middle line, the neutral axis, will remain the same length. On the upper side of the neutral axis in Fig. 5 the act of bending pulls the molecules farther apart against their attraction, storing up energy in the potential form just as it is stored up in a raised weight. On the lower side the molecules are pushed together against the centrifugal force, due to their motion, and in their capability to do work by flying out again potential energy is stored, just as truly as in the case of the lifted weight. You cannot stick a tool into it except under great pressure, because the molecules resist being crowded apart. But with the continued application of heat (i.e., with the continued increase in the velocity of these molecules), the centrifugal force gets stronger all the time, and on accqunt of the greater distance between them the attractive force of the molecules gets weaker, and the solid that we are heating begins, as we say, to "soften up." The attractive force, while still sufficient to hold the molecules together, is not enough greater than the disruptive or centrifugal force to offer serious resistance to change of form. The body can be bent easily, a blunt stick can be pushed into it, and finally it cannot hold up its own weight, but goes running down in the liquid state, and has to be held up by the sides of the containing vessel. Even now the molecules have considerable mutual attraction. Pick a drop of the fluid up on a rod and you will see that it coheres in a globular form, but this cohesion is easily overcome by the weight of the mass so that it takes the shape of the containing vessel, pours, allows the finger to be run through it with only moderate resistance, and has all of the attributes which to our senses characterize a thing as a liquid.

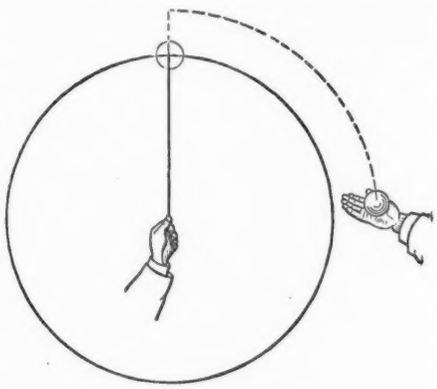


FIG. 4

Now let us take a pound of water in this condition, just after it has changed from the solid form, ice, and put it into a flask over an alcohol flame. Alcohol is made up of hydrogen and carbon, and you know that these substances have a strong affinity for oxygen, of which there is a plentiful supply in the air. In rushing together, these atoms of oxygen, hydrogen and carbon acquire an enormous velocity, just as a body acquires velocity under the pull of gravity in falling to the earth. The high rate of motion thus set up is what we recognize as high temperature, and the combination is combustion.

Remember that if we had a microscope powerful enough to magnify this flask up to the size of the earth, we should find it not to consist of a hard, shiny, continuous wall, but of a lot of objects in size somewhere between shot and footballs, in a state of violent agitation, and that it is this agitation which we feel and recognize as temperature. Now the molecules of the glass are moving at a rate corresponding with a temperature of 32 degrees, that of the water which the flask contains, and here come bumping into them a lot of molecules having an amount of motion corresponding to 2000 or 3000 degrees. Well, you know what happens when a swiftly moving body meets a slowly moving one. The slowly moving one is hurried along, and the swiftly moving one loses the energy which the other gains. In this case the molecules of the glass are accelerated (their temperature is raised) and those of the gaseous products of combustion are slowed down (their temperature is reduced). The glass molecules pass the motion along, like a string of billiard balls, to the molecules of the water, and they take up the energy furnished by the falling together of the atoms of hydrogen and oxygen, and the temperature of the water begins to increase.

Difference Between Quantity and Intensity of Heat

If our senses were sufficiently quantitative, if we could see finely enough and measure closely enough, we would see the pound of water at first contract in volume, under the influence of the added heat, and it would do this until it got to 39 degrees, when it would commence to expand. In order to keep track of the process and to measure and compare results we must have a unit whereby to measure the amount of heat that is going into the flask, and the amount of heat necessary to raise a pound of water one degree Fahrenheit at its point of maximum density, i.e., from 39 to 40 degrees, has been generally adopted as the unit whereby to measure *quantities* of heat. You will readily realize the difference between this *quantity* of heat (proportional to the energy exerted) required to raise the temperature of a given amount of water a

given number of degrees, and the *intensity* of the heat vibrations indicated by the thermometer. The one is the amount of energy applied in the form of heat, and the other a measure of the activity of the molecules induced by that energy, the temperature. It is evident that there is a greater *quantity* of heat in a hogshead of water at 60 degrees than in a teaspoonful at the boiling *temperature,* as may be readily comprehended by conceiving the comparative amounts of fuel required to produce the two from water at 32 degrees.

I have said that the amount of heat required to raise a pound of water from 39 to 40 degrees Fahrenheit, had been generally adopted as the unit of heat, or "British thermal unit," as it is called. Some authorities, among them Prof. Cecil H. Peabody, however, use the amount required to raise a pound of water from 62 to 63 degrees Fahrenheit, because this is more nearly an average temperature at which experiments involving the value will be made. The difference is small, but apparent in the tables. Professor Peabody has made separate tables advancing by even degrees, and by even pounds in English units, as well as tables in the Centigrade-metric units. The table on page 586 is a reproduction of the fifth page of his table advancing by even degrees.

Let us suppose that the heating of the flask of water has continued until the temperature has reached 212 degrees, at which temperature, if the process has been conducted under an absolute pressure of 14.697 pounds (see second column of the table, opposite "212"), the temperature will cease to rise and the water will commence to boil. This is about the pressure of the atmosphere at sea level, varying slightly as the barometer shows, so that 212 degrees is commonly spoken of as the boiling point of water; but this is true only at this pressure. If the pressure drops to 14.407 pounds, the water will boil at 211 degrees, or at 11.52 pounds it will boil at 200 degrees. At high altitudes, where the pressure of the atmosphere is low, water boils at so low a temperature that it takes much longer to cook food by boiling. Each pressure has a corresponding boiling temperature, and column 2 of the table gives the pressures under which water will boil at the corresponding temperatures in column 1.

Consider for a moment why this is so, and what has been occurring. The molecules of the water have been batted into increasing velocity by the impact of the molecules of the glass, which have passed through to the water the increased velocity and energy which they got from the impact of the swiftly moving molecules of the heated gases of combustion. The molecules of the water move at an increased velocity, their centrifugal force is increased, and they swing in greater orbits. A pound of water is about a pint. To raise that pound of water one degree, to get up the increased velocity which affects our senses or our thermometers to the value of one degree, as much work is exerted upon that pint of molecules as would raise 778 pounds a foot in hight, this being the amount of energy found by experiment to be equivalent to the British thermal unit.

Column 3 of the table shows the number of British thermal units required to raise the pound of water from 32 degrees to the given temperatures. If the specific heat were constant, that is, if it took just as much heat to raise a pound of water from 211 to 212, as it did from 32 to 33, and so all along the scale, it would take $212 - 32 = 180$ B.t.u. to raise it from 32 to 212, whereas Peabody's table gives 180.8; Porter's table (that of Kent's and the usual handbooks), 180.9. If, then, we could see closely enough and quantitatively enough we should have seen, say 180.8 B.t.u. going into our pound of water when it began to boil.

What does it mean, this "boiling," and why, notwithstanding the continued absorption of heat, will the temperature not rise above 212 degrees?

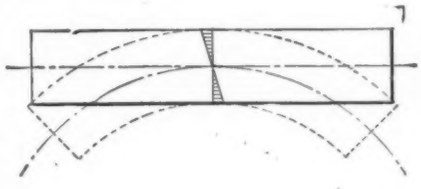


FIG. 5

We have seen the molecules increasing in activity until they reach that velocity which in connection with their mass we recognize as 212 degrees hot. At this point their centrifugal force becomes such that it overcomes the attractive force and the molecules fly out from each other, as do missiles from a sling-shot when the string is released, and, battering back the wall of water surrounding them, form a bubble of steam. The water is held together not only by its own cohesion, but by the pressure upon its surface. The greater this pressure the greater kinetic energy (temperature) the molecules must have to overcome the combined resistance. With a pressure of 0.089 of a pound absolute, water will boil at 32 degrees (see column 2, Kent's table), because with this low pressure upon the surface of the water it is so much easier to separate the molecules that the centrifugal force, due to the amount of motion which we recognize as 32 degrees will do it.

If we imagine the above experiment performed in a closed vessel from which all the air had been exhausted, which contained, in other words, nothing but the pound of water, we should see enough of the water evaporate at 32 degrees to raise the pressure in the flask to 0.089 of a pound. Then as the temperature arose more steam would be generated with a consequent rise in pressure; and so all the way from 32 degrees up, each pressure has its corresponding boiling point, and each temperature its corresponding pressure, as the table shows.

Where the Extra Heat Goes

Returning to the experiment at 212 degrees, we should find that while it took but 180.8 B.t.u., to raise the water from 32 to 212 degrees, it took 965.7 or 965.8 (see column 6 of Kent's and column 5 of Peabody's tables) more of the same units to boil it all away, without raising its temperature in the least. Where has this heat gone?

A part of it has gone into external work, increasing the volume of the water into that of the steam under the pressure of the atmosphere.

One pound of water at 212 degrees has a volume of 0.0167 of a cubic foot.

One pound of steam at 212 degrees has a volume (see column 8, Peabody's table) of 26.6 cubic feet; Kent's table gives it as 26.36.

The increase in volume has been

$$26.6 - 0.0167 = 26.5833 \textit{ cubic feet.}$$

Imagine this water to be in the bottom of a cylinder having an area of one square foot. The atmosphere would exert a pressure upon its surface of 14.697 pounds per square inch (see column 2), or:

$$144 \times 14.697 = 2116.368 \textit{ pounds}$$

on the square foot of surface of the liquid. When the water has been converted into steam this pressure will have been pushed back 26.5833 feet, this being the difference in volume between the steam and water, as found above, and this number of feet in hight of a tube one square foot in section being necessary to give that volume. The work done is, therefore:

$$2116.368 \times 26.5833 = 56260 \textit{ foot-pounds.}$$

As one foot-pound is equivalent to 778 heat units, the heat equivalent of this external work is:

$$56260 \textit{ F.} \div 778 = 72.3 \textit{ B.t.u.}$$

In this way column 7 of the Peabody table is computed.

Of the 965.8 B.t.u. (or 965.7, according to the table we use) necessary to evaporate a pound of water at 212 degrees into steam of the same temperature, to evaporate a pound of water "from and at 212 degrees," as it is usually said, 72.3 B.t.u. are required to do the external work of pushing back the surroundings to make room for the resulting steam. Then $965.8 - 72.3 = 893.5$ B.t.u. (column 6) have been necessary to overcome the cohesion of the molecules, to disintegrate the water and break it up into steam.

Think for a second what that means. One B.t.u. is equivalent to 778 foot-pounds of work. Converted into mechanical energy by a machine of 100 per cent. efficiency it would lift a weight of 778 pounds one foot high. The 893.5 such units necessary to separate the molecules

of a pound of water against their mutual attraction are equivalent to:

$893.5 \times 778 = 695{,}143$ *foot-pounds,*

enough to lift that pound of water to a hight of over 130 miles; enough to lift a weight of 35 tons nearly 10 feet. There was no change in the temperature during the operation. The water and the steam both remained at 212 degrees. Then there could have been no increase in the kinetic energy, which manifests itself as temperature. The 965.8 B.t.u. applied to the evaporation went, then, into potential energy, the energy of position, some in pushing back the surrounding atmosphere, which can restore this energy by coming together again when the steam is condensed, some in lifting apart the molecules of the water.

The heat thus lost from sight as heat is spoken of as "latent heat," while that which affects the temperature is the "sensible heat." The latter in this case, being the heat required to raise the water to the boiling point, is called the "heat of the liquid" and is designated in Peabody's tables and in his books on thermodynamics by q, but is more generally indicated by h (see column 4 Kent's table). The "latent heat" Peabody calls more properly the "heat of vaporization" and indicates it by r (see column 5, Peabody; column 6, Kent). The sum of the heat of the liquid and the heat of vaporization is the "Total Heat" (column 4, Peabody; column 5, Kent) required to raise a pound of water from 32 degrees to the given temperature, and evaporate it at that temperature and the corresponding pressure. Peabody indicates this value by the Greek letter lambda λ, and Kent and others by the letter H.

Difficulty of Determining the Specific Volume

Of the remaining columns of the table we will reserve an explanation of Peabody's column 8 for a later lecture. Column 9 in Peabody's table and column 8 in Kent's table give the "specific volume", i. e., the number of cubic feet in a pound of steam at the corresponding pressures and temperatures. Peabody makes a pound of dry saturated steam at 212 degrees occupy a volume of 26.6, and Kent 26.36, cubic feet.

This is one of the most difficult things to determine about steam, on account of the practical impossibility of telling when the last trace of moisture has been evaporated. Reviewing our imaginary experiment of boiling a pound of water in a flask, we first saw it increase in temperature from 32 to 212 degrees, then, notwithstanding the continued application and absorption of heat, we saw the temperature remain at 212 degrees while the water boiled away. If the operation took place in a flask of sufficient volume and the air were excluded or crowded out by the steam, we should have at the instant that the last pair of molecules split up, at the moment that the last trace of moisture was evaporated, something more than 26 cubic feet of "dry saturated" steam. "Dry" because the last trace of moisture is out of it; "saturated", because it has

THE PHYSICAL PROPERTIES OF DRY SATURATED STEAM

1	2	3	4	5	6	7	8	9
Vacuum Gauge, Inches of Mercury.	Absolute Pressure, lbs. per square inch.	Temperature Fahrenheit.	Total Heat above 32° F.		Latent Heat $L = H - h$. Heat-units.	Relative Volume. Vol. of Water at 39° F. = 1.	Volume, Cu. ft. in 1 lb. of Steam.	Weight of 1 cu. ft. Steam, lb.
			In the Water h Heat-units.	In the Steam H Heat-units.				
29.74	.089	32	0	1091.7	1091.7	208080	3333.3	.00030
29.67	.122	40	8.	1094.1	1086.1	151330	2472.2	.00040
29.56	.176	50	18.	1097.2	1079.2	107630	1724.1	.00058
29.40	.254	60	28.01	1100.2	1072.2	76370	1223.4	.00082
29.19	.359	70	38.02	1103.3	1065.3	54660	875.61	.00115
28.90	.502	80	48.04	1106.3	1058.3	39690	635.80	.00158
28.51	.692	90	58.06	1109.4	1051.3	29290	469.20	.00213
28.00	.943	100	68.08	1112.4	1044.4	21830	349.70	.00286
27.88	1	102.1	70.09	1113.1	1043.0	20823	334.23	.00299
25.85	2	126.3	94.44	1120.5	1026.0	10730	173.23	.00577
23.83	3	141.6	109.9	1125.1	1015.3	7325	117.98	.00848
21.78	4	153.1	121.4	1128.6	1007.2	5588	89.80	.01112
19.74	5	162.3	130.7	1131.4	1000.7	4530	72.50	.01873
17.70	6	170.1	138.6	1133.8	995.2	3816	61.10	.01631
15.67	7	176.9	145.4	1135.9	990.5	3302	53.00	.01887
13.63	8	182.9	151.5	1137.7	986.2	2912	46.60	.02140
11.60	9	188.3	156.9	1139.4	982.4	2607	41.82	.02391
9.56	10	193.2	161.9	1140.9	979.0	2361	37.80	.02641
7.52	11	197.8	166.5	1142.3	975.8	2159	34.61	.02889
5.49	12	202.0	170.7	1143.5	972.8	1990	31.90	.03136
3.45	13	205.9	174.7	1144.7	970.0	1846	29.58	.03381
1.41	14	209.6	178.4	1145.9	967.4	1721	27.59	.03625
Gauge Pressure lbs. per sq. in.	14.7	212	180.9	1146.6	965.7	1646	26.36	.03794
0.304	15	213.0	181.9	1146.9	965.0	1614	25.87	.03868
1.3	16	216.3	185.3	1147.9	962.7	1519	24.33	.04110
2.3	17	219.4	188.4	1148.9	960.5	1434	22.98	.04352
3.3	18	222.4	191.4	1149 8	958.3	1359	21.78	.04592
4.3	19	225.2	194.3	1150.6	956.3	1292	20.70	.04831
5.3	20	227.9	197.0	1151.5	954.4	1231	19.72	.05070
6.3	21	230.5	199.7	1152.2	952.6	1176	18.84	.05308
7.3	22	233.0	202.2	1153.0	950.8	1126	18.03	.05545
8.3	23	235.4	204.7	.7	949.1	1080	17.30	.05782
9.3	24	237.8	207.0	1154.5	947.4	1038	16.62	.06018
10.3	25	240.0	209.3	1155.1	945.8	998.4	15.99	.06253
11.3	26	242.2	211.5	.8	944.3	962.3	15.42	.06487
12.3	27	244.3	213.7	1156.4	942.8	928.8	14.88	.06721
13.3	28	246.3	215.7	1157.1	941.3	897.6	14.38	.06955
14.3	29	248.3	217.8	.7	939.9	868.5	13.91	.07188
15.3	30	250.2	219.7	1158.3	938.9	841.3	13.48	.07420
16.3	31	252.1	221.6	.8	937.2	815 8	13.07	.07652
17.3	32	254.0	223.5	1159.4	935.9	791.8	12.68	.07884
18.3	33	255.7	225.3	.9	934.6	769.2	12.32	.08115
19.3	34	257.5	227.1	1160.5	933.4	748.0	11.98	.08346
20.3	35	259.2	228.8	1161.0	932.2	727.9	11.66	.08576
21.3	36	260.8	230.5	1161.5	931.0	708.8	11.36	.08806
22.3	37	262.5	232.1	1162.0	929.8	690.8	11.07	.09035

A page from Kent's "Pocket-book."

1	2	3	4	5	6	7	8	9	10	11
Temperature, Degrees Fahr. t	Pressure, Pounds per Square Inch. p	Heat of the Liquid. q	Total Heat. λ	Heat of Vaporization. r	Heat equivalent of Internal Work. ρ	Heat equivalent of External Work. Apu	Entropy of the Liquid. $\int \frac{cdt}{T}$	Specific Volume. s	Density. Weight, in Pounds, of one Cubic Foot. γ	Temperature, Degrees Fahr. t
184	8.192_{181}	152.6	1138.1	985.5	915.7	69.8	0.2699	46.03_{94}	0.02172_{46}	184
185	8.373_{185}	153.6	1138.4	984.8	914.9	69.9	0.2714	45.08_{92}	0.02218_{46}	185
186	8.558_{188}	154.6	1138.7	984.1	914.1	70.0	0.2730	44.17_{89}	0.02264_{47}	186
187	8.746_{191}	155.6	1139.0	983.4	913.4	70.0	0.2745	43.28_{87}	0.02311_{47}	187
188	8.937_{195}	156.6	1139.3	982.7	912.6	70.1	0.2761	42.41_{85}	0.02358_{48}	188
189	9.132_{198}	157.6	1139.6	982.0	901.8	70.2	0.2777	41.56_{83}	0.02406_{49}	189
190	9.330_{202}	158.6	1139.9	981.3	911.0	70.3	0.2792	40.73_{81}	0.02455_{50}	190
191	9.532_{206}	159.6	1140.2	980.6	910.2	70.4	0.2808	39.92_{79}	0.02505_{51}	191
192	9.738_{209}	160.6	1140.5	979.9	909.4	70.5	0.2823	39.13_{78}	0.02556_{52}	192
193	9.947_{213}	161.6	1140.8	979.2	908.6	70.6	0.2838	38.35_{76}	0.02608_{52}	193
194	10.160_{217}	162.6	1141.1	978.5	907.8	70.7	0.2854	37.59_{74}	0.02660_{54}	194
195	10.377_{221}	163.7	1141.4	977.7	906.9	70.8	0.2869	36.85_{72}	0.02714_{54}	195
196	10.598_{224}	164.7	1141.7	977.0	906.2	70.8	0.2885	36.13_{71}	0.02768_{55}	196
197	10.822_{229}	165.7	1142.0	976.3	905.4	70.9	0.2900	35.42_{69}	0.02823_{56}	197
198	11.051_{232}	166.7	1142.3	975.6	904.6	71.0	0.2915	34.73_{67}	0.02879_{57}	198
199	11.283_{237}	167.7	1142.6	974.9	903.8	71.1	0.2930	34.06_{66}	0.02936_{58}	199
200	11.520_{241}	168.7	1142.9	974.2	903.0	71.2	0.2946	33.40_{64}	0.02994_{59}	200
201	11.761_{244}	169.7	1143.2	973.5	902.2	71.3	0.2961	32.76_{63}	0.03053_{59}	201
202	12.005_{249}	170.7	1143.6	972.9	901.5	71.4	0.2976	32.13_{61}	0.03112_{59}	202
203	12.254_{254}	171.7	1143.9	972.2	900.8	71.4	0.2991	31.52_{60}	0.03173_{62}	203
204	12.508_{257}	172.7	1144.2	971.5	900.0	71.5	0.3007	30.92_{59}	0.03235_{62}	204
205	12.765_{263}	173.7	1144.5	970.8	899.2	71.6	0.3022	30.33_{57}	0.03297_{63}	205
206	13.028_{266}	174.7	1144.8	970.1	898.4	71.7	0.3037	29.76_{57}	0.03361_{65}	206
207	13.294_{271}	175.8	1145.1	969.3	897.5	71.8	0.3052	29.19_{56}	0.03426_{67}	207
208	13.565_{276}	176.8	1145.4	968.6	896.7	71.9	0.3067	28.63_{54}	0.03493_{67}	208
209	13.841_{281}	177.8	1145.7	967.9	896.0	71.9	0.3082	28.09_{52}	0.03560_{68}	209
210	14.122_{285}	178.8	1146.0	967.2	895.2	72.0	0.3097	27.57_{52}	0.03628_{69}	210
211	14.407_{290}	179.8	1146.3	966.5	894.4	72.1	0.3112	27.05_{45}	0.03697_{69}	211
212	14.697_{293}	180.8	1146.6	965.8	893.5	72.3	0.3127	26.60_{44}	0.03766_{72}	212
213	14.990_{299}	181.8	1146.9	965.1	892.6	72.5	0.3142	26.16_{49}	0.03824_{72}	213
214	15.289_{303}	182.8	1147.2	964.4	891.8	72.6	0.3157	25.67_{48}	0.03896_{73}	214
215	15.592_{309}	183.8	1147.5	963.7	891.0	72.7	0.3172	25.19_{46}	0.03969_{74}	215
216	15.901_{313}	184.8	1147.8	963.0	890.2	72.8	0.3187	24.73_{45}	0.04043_{75}	216
217	16.214_{319}	185.8	1148.1	962.3	889.5	72.8	0.3202	24.28_{44}	0.04118_{76}	217
218	16.533_{324}	186.8	1148.4	961.6	888.7	72.9	0.3217	23.84_{43}	0.04194_{78}	218
219	16.857_{329}	187.8	1148.7	960.9	887.9	73.0	0.3232	23.41_{43}	0.04272_{80}	219
220	17.186_{335}	188.9	1149.0	960.1	887.1	73.0	0.3246	22.98_{42}	0.04352_{80}	220
221	17.521_{340}	189.9	1149.3	959.4	886.3	73.1	0.3261	22.56_{41}	0.04432_{82}	221
222	17.861_{345}	190.9	1149.7	958 8	885.6	73.2	0.3276	22.15_{39}	0.04514_{82}	222
223	18.206_{351}	191.9	1150.0	958.1	884.8	73.3	0.3291	21.76_{39}	0.04596_{84}	223

A page from Professor Peabody's Table.

got all the water it can hold and still remain as steam. If now the application of heat is continued the temperature will rise. Steam free from water can be heated like any other gas. It is only when there is water present to take up the heat by evaporation that the temperature fails to rise. Steam thus heated above the temperature due to its pressure is said to be "superheated."

If in such superheated steam, water is exposed a sufficient time, it will take up heat from the steam and evaporate, and the steam will thus be cooled down to the temperature corresponding to its pressure. It cannot be further cooled from this cause for the water will not evaporate at a temperature below that due to the pressure, so that the steam is now said to be in the "dry saturated" condition. Any abstraction of heat, as by radiation, means that the velocity of the molecules is being reduced, and as in the dry saturated condition they have just enough velocity to give them centrifugal force enough to break away from each other, any loss of velocity causes them to fall again within each other's attraction and to become united again, forming water. This is the phenomenon of condensation. Now it is enormously difficult to handle a pound of steam in a vessel the walls of which are themselves sensitive to heat changes, and to observe its volume at the instant that the last trace of moisture has disappeared and before superheating commences. This is especially difficult because, of a volume of 26 cubic feet of steam, one portion may be superheated, while condensation has set in in another portion, and determinations of temperature and dryness have to be made with thermometers which require some time to adjust themselves to a change in conditions. It is no wonder, then, that different experimenters fail to absolutely agree upon this point.

The tenth column of Peabody's and the ninth column of Kent's table give the density or weight of one cubic foot of steam of the corresponding pressures and temperatures. As this is the reciprocal of the corresponding value in column 9 (1 divided by that quantity), it is subject to the same variations.

Kent's table has a column, the seventh, which Peabody's has not. It gives the relative volume of the steam and the water from which it is made. For example, steam at 212 degrees and atmospheric pressure occupies 1646 times as much space as does the water from which it is made at its point of maximum density.

The intermediate numbers in columns 2, 9 and 10 of Peabody's table are the differences between the values above and below them, and show the variation per degree of tempreature. They may be used for interpolation for fractional values not given by the table.

Electric Propulsion for Steamships

By S. Snuyff

At first sight it would seem that the losses of energy involved in the electric transmission of power from the prime mover to the propeller of a steamship would render the scheme impracticable. The importance of this loss, however, disappears at once when one takes into consideration that the present system of turbine propulsion involves two sources of energy loss, namely, the restricted velocity of the turbines, necessitating an increased consumption of steam as compared with normally running turbines, and the high rotative speed of the screw propellers, resulting in a lower efficiency. In all turbine-driven vessels the turbines run too slow, and the propellers too fast. The resulting losses are not easy to ascertain, but they are very likely to be at least as great as 10 per cent. Consequently, despite the losses of energy entailed by electrical transmission, there may be a gain in total efficiency as compared with direct turbine driving, as the electric motor can be run at very moderate speeds and the independent turbo-dynamo can be driven at a suitable rate of revolution and thereby at maximum economy.

The efficiency of electric dynamos and motors does not vary widely with different loads and speeds, especially when they are constructed with this requirement in view. The renewed application of commutation poles is of the greatest importance in this matter.

The question must be considered, however, from another point of view, namely, the required weight of the machinery. This point, too, is not as serious as it might seem at first glance. As turbines for electric driving run at much higher speeds, the weight will be much less than that of ordinary direct-propulsion turbines. A turbine-dynamo of, say, 5000 kilowatts ability, corresponding to about 7000 turbine horse-power, weighs with condenser and dynamo about 200 tons and runs at some 700 to 800 revolutions per minute. Two electric motors to run at about 100 revolutions per minute can be built to weigh about 50 tons each. The complete 7000-horse-power plant thus can be constructed to weigh not more than 300 tons.

In commercial vessels the weight of turbines for the same capacity ahead and astern will amount to about 200 to 250 tons. For war vessels, however, the weight of machinery must be taken greater, as separate turbines are necessary for cruising. Indeed, the total weight of machinery will be about the same whether electric transmission be adopted or not. In the case of the "Dreadnought," the turbines are of the same weight that reciprocating engines would have been, and the total weight of turbine-electric propulsion machinery very closely approximates that of reciprocating engines. As regards costs and space, also, there cannot be greater differences, especially in the case of war vessels, when comparing electric with direct turbine driving.

Granted that with electric driving the steam economy, weight, costs and space are practically the same, one will ask: What are the advantages gained by electric driving? The most important advantage lies in the reversing power. The electric motor, when reversed, not only can work at its full capacity, but may be heavily overloaded, as it is only for short periods that reverse running is necessary. This means an important advantage above ordinary turbine propulsion, where the backing power is seldom more than half of the going ahead power. Furthermore, manipulations for manœuvering are simplified, as the reversing of the propellers only involves the manipulation of electric switches. The turbine-dynamo runs continuously in the same direction, and need not be subjected to great load variations, as the load, when the motor is switched off and a brake applied on the shaft, may be taken up by water resistances until the motor takes current again for the reverse motion. As the switching and application of the brake can be arranged partly automatically, it is perhaps possible to put the whole of the manœuvering in the hands of the officer on the bridge, doing away with the telegraph.

Another important advantage lies in the fact that the generating machinery can be located in any desirable part of the ship, since it is wholly independent of the propeller shafts. When the turbines are placed with their axes perpendicular to the line of movement of the ship there will, moreover, be obtained a steadying effect on the vessel against rolling, as with Schlick's gyroscope.

A third advantage is that the number of propellers, again, may be reduced to one or two, as with a normal speed of 100 to 200 revolutions per minute the area presented to the blades of the propellers is sufficient.

Mayor McClellan of New York has vetoed a bill providing that no person shall be permitted to operate any engine, irrespective of the motive fluid employed, exceeding 10 horse-power unless the operator be a licensed steam engineer. The mayor points out that the law would apply to elevators, naphtha launches, automobiles and motor boats, and probably to trolley cars and the electric locomotives used on the elevated roads, concluding that the inherent danger which was thought to be remedied by the original law was the prevention of the explosion of steam boilers, and that it is obvious that there is no such danger attendant upon the operation of a simple electric motor.

Indicator Diagrams from a Canadian Crude-oil Engine

By H. Addison Johnston

The Johnston crude-oil engine is a type of internal-combustion motor which has been developed by the writer and is now in general use in Canada. In this motor the fuel, which may be any liquid hydrocarbon, crude or refined, is sprayed into the cylinder by compressed air at the end of the compression stroke. The compression pressure used is generally from 135 to 150 pounds. As the oil enters the cylinder it strikes on a deflector or spreader which throws a portion of the spray against an igniter point located on the end of the piston, which igniter is maintained at a temperature above the ignition point of the fuel by the heat of the successive combustions. The fuel is immediately fired upon entering and burns for an appreciable period, which may be predetermined by the designer. The cylinder, piston and combustion chamber are so constructed that the temperature of the interior surfaces of the combustion chamber is sufficiently high to prevent the condensation of tar or other carbonaceous material upon them, and no water-jacketed surface is in contact with the charge during the injection and burning of the oil or during the early part of the expansion stroke. Fig. 1 illustrates this construction, and Figs. 2 to 10 show indicator diagrams taken from various Johnston engines. Fig. 2 is an average normal diagram, showing 97 pounds mean effective pressure. It will be noted that the combustion line, or explosion line, as it would be called in a gas engine, is quite vertical.

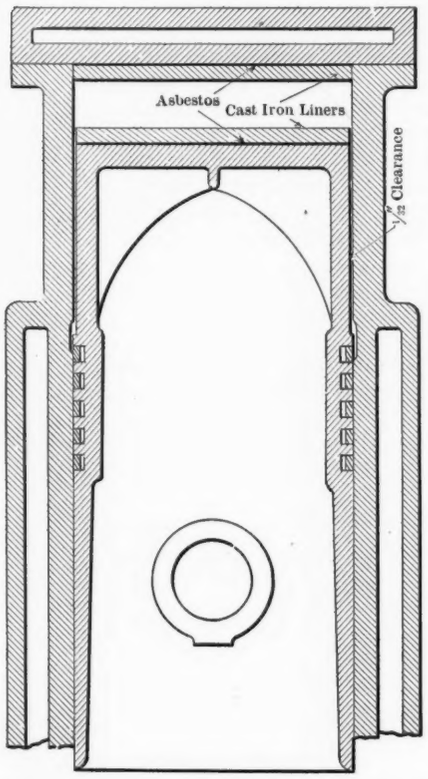


FIG. 1. LONGITUDINAL SECTION OF CYLINDER OF JOHNSTON ENGINE

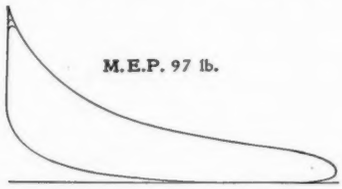


FIG. 2. A NORMAL DIAGRAM; SCALE: 300 LB.

Fig. 3 shows the effect of opening the fuel admission valve too early in the stroke. The maximum pressure is reached before the crank reaches the center, and a slight loop is formed in the diagram. In Fig. 4 the fuel is injected and ignited at the proper time, but burns very slowly, the maximum temperature being obtained a considerable time after the piston has started to move forward.

It would naturally be expected that in a gasolene engine the inflammation of the charge would be completed in much less time after ignition than in this engine using a spray of heavy fuel oil; but the reverse has proved to be the case. None of the engines yet built has been provided with any mechanism for changing the timing of the fuel valve, which, in this engine, corresponds to the ignition timer on the usual type of engine.

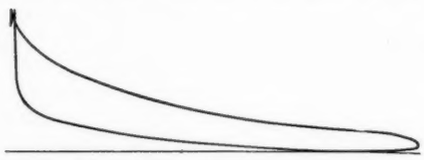


FIG. 3. IGNITION A TRIFLE EARLY; CORRECTED SCALE: 400 LB.

Fig. 5 is a "double exposure;" one diagram was taken when the engine was running very slowly, and the other at full speed. The pressures are approximately the same on both. It may be noted that in the high-speed diagram the inertia of the indicator drum has caused the cord to stretch and thus lengthen the diagram. The fuel valve is usually set to open about five degrees of crank travel before the center. The time interval between the opening of the fuel valve and the ignition of the fuel is very small, and only a very slight difference can be noted between the areas of the two indicator diagrams.

The diagram in Fig. 6 was taken when the load was suddenly thrown off. The action of the governor in cutting off the oil supply is distinctly shown, while the compression pressure is seen to remain constant. Fig. 7 is a no-load diagram. This is fairly representative of the type, though the ignition is often not so nearly vertical as here shown; sometimes it falls to the horizontal or even below it, giving the suggestion of an isothermal.

Fig. 8 is the record-breaking diagram of this type of engine, the mean effective pressure being 120 pounds; in reality it is a "freak." This diagram was obtained when the engine was being started; the cylinder was cold and the previous charge had not fired, some of the oil remained in the cylinder and formed a fine, rich mixture, which fired itself at the proper time in the succeeding cycle. While this diagram is the record of a true explosion, it will be noticed that there is comparatively little vibration of the pencil at the beginning of the expansion stroke.

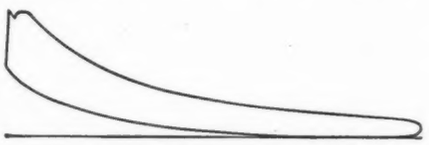


FIG. 4. A SLOW-BURNING MIXTURE; CORRECTED SCALE: 415 LB.

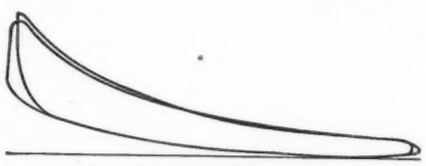


FIG. 5. SUCCESSIVE DIAGRAMS AT LOW AND HIGH SPEEDS; CORRECTED SCALE: 415 LB.

The principal difficulty in the development of this type of engine was experienced in preventing the formation of explosion waves in the burning charge. These waves caused severe pounding in the cylinder, and the laws governing their formation were only discovered after many months of tedious experimenting.

The ordinary type of explosion-wave diagram is shown by Fig. 9, from which it

FIG. 6. SUCCESSIVE DIAGRAMS DURING LOAD REDUCTION; CORRECTED SCALE: 395 LB.

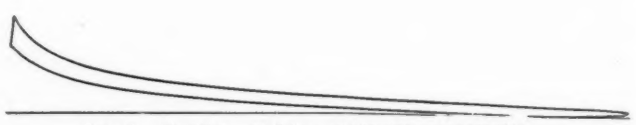


FIG. 7. TYPICAL NO-LOAD DIAGRAM; CORRECTED SCALE: 400 LB.

will be seen that though the fuel was not injected nor ignited until the proper time at the end of the compression stroke, an extremely violent impulse was given to the indicator piston, which caused the vibrations shown in the diagram. A loud knock or pound with a metallic ring occurs at the beginning of each stroke, when diagrams such as this are obtained. It was first thought that these were caused by too early injection of the fuel, but it was soon found out that the time of injection had very little to do with the wave formation. Fig. 10 shows a diagram which indicates that explosion waves formed a considerable time after the piston had started to move forward, the injection being purposely delayed.

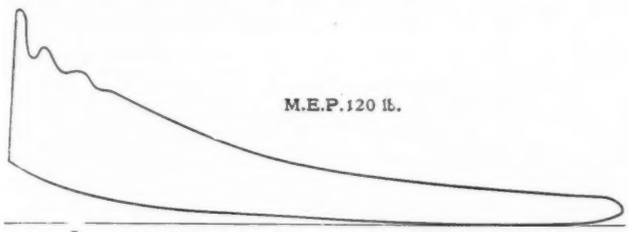


FIG. 8. AN ABNORMAL DIAGRAM; CORRECTED SCALE: 355 LB.

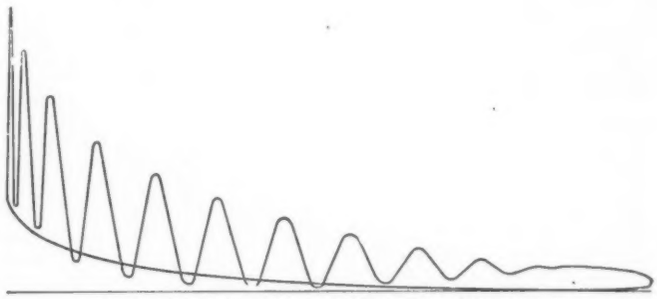


FIG. 9. DIAGRAM PRODUCED BY EXPLOSION WAVES

For many months during the development of the engine, every diagram taken was of the type of Fig. 9 or Fig. 10, but since the laws governing the formation of explosion waves have been discovered, engines may now be built in which these waves will not form. The prevailing idea that explosion waves are caused by pockets in the combustion chamber is not true, at least, in this type of engine, as none of the engines experimented with had any pockets whatever. The violence of the blows struck by these explosion waves can hardly be imagined by those who are unfamiliar with them. In many cases the pencil lead in the indicator arm has been snapped off on both ends when the indicator cock was opened.

FIG. 10. EXPLOSION WAVES WITH DELAYED IGNITION; CORRECTED SCALE: 400 LB.

These diagrams have been picked out from a bundle of about three thousand taken in the three years during which the engine has been in process of development. The spring used in all diagrams was 300 pounds.

[The sizes of some of the diagrams have been changed by reproduction, but the corrected spring scales are stated in these cases.—EDITORS.]

A mixture of litharge and glycerin applied to iron work will fill up porous spots and make the work tight.

Mains and Fittings for Gas-power Plants

BY L. L. BREWER

In view of the rapid growth of gas-power plants, in both number and size, it would seem that the proper design of gas mains for such plants should be of some interest; for surely the design and installation of steam mains is an important feature of steam-power plants.

The writer has found the prevailing impression to be that it is only essential that gas mains should be large enough to convey the desired volume of gas and that they should be tight. While these are the chief essentials, there are others of considerable importance which merit enumeration and discussion.

The simple proposition of delivering a certain volume of gas of certain density through a known length of pipe when the head is also known is but a matter of simple calculation. A formula in common use for the flow of gas in pipes is as follows:

$$Q = 1350\, d^2 \sqrt{\frac{d\,h}{s\,l}},$$

in which

Q = the quantity of gas in cubic feet per hour,
d = the diameter of the pipe in inches,
h = the head, in inches, of water,
s = the specific gravity of the gas, air being 1, and
l = the length of the pipe in yards. (If l is in feet, substitute 2337 for 1350.)

This formula is for a straight length of pipe and when the run contains several bends, valves, etc., the quantity of gas delivered is, of course, less. Just how much less is a quantity which can be approximated only, and no hard-and-fast rules are applicable to accuracy.

QUALITY A GOVERNING FACTOR

A factor which governs the design of gas mains in a large degree is the quality of the gas delivered, and this is especially true of some power gases; for a gas main, where blast-furnace gas is used, often performs other functions than that of merely conveying the gas. It may be, and in many places is, part of the purification scheme.

The generalities which follow are equally true of any power gas and while extreme conditions are discussed, it should be remembered that actual conditions in any plant must govern the design for that plant.

In accordance with the light pressures dealt with, gas mains are sometimes made of thin, sheet-steel spiral sections riveted. The velocity of gas through short mains is sometimes as high as 30 feet per second, while in longer mains it is kept as low as 10 feet per second. It is obvious that the higher the velocity, the smaller will be the diameter of the pipe necessary to convey a certain volume of gas; but other considerations make it desirable to limit the velocity to about the maximum stated above. One of these is that the power necessary to move the gas varies as the square of the velocity and while the comparative amount of power is small, it should not be overlooked.

Furthermore, in most gas-power plants advantage is taken of the action of the gas in flowing through pipes to utilize it for partially removing impurities in the gas.

TO GUARD AGAINST EXPLOSIONS

The possibility of explosion is always present in gas mains, due to the fact that sufficient air may get in to form an explosive mixture and some condition may arise which will cause combustion. It is well, therefore, to provide for relief of the pressure caused by an accidental explosion and this is best done by water-sealing several or all dust pockets. This has the added advantage that under this condition dust may be removed from the pockets while the main is in use.

In cases where gas mains occasionally become filled with air, as for instance where they lead out from scrubbers and while the latter are being cleaned, there must be provided air escape-valves which may be opened to permit the entire volume of air to be discharged into the atmosphere when the gas is again turned into the mains. This injunction obviously applies to all classes of gas-power plants

where any part of the gas main is liable to be opened up to the atmosphere.

The importance of keeping a gas main tight cannot be over-estimated, particularly when a partial vacuum is maintained in the mains, as in suction producer-gas plants, in which case there is a constant tendency for air to leak into the mains. Tight joints are hard to make and preserve and it is therefore best to use water-seals, which are tight, in place of doors and some other fittings which are liable not to be tight.

How to Detect Leakage

Leakage of a small amount of air is sometimes difficult to detect, especially in pipes under partial vacuum. In pipes under pressure, an examination may be made with the aid of a candle and often only with the aid of one's nose. In the first case, however, a very conclusive though not simple method is to sample the gas at various points in the line and make a chemical analysis of the samples. If the air which has leaked in has combined with the gas to burn it, it will cause an increase in the percentage of carbon dioxide (CO_2) and of nitrogen (N) in the gas samples taken from the point nearer the engine.

In a plant where continuous operation over a considerable period of time is necessary, cleaning apparatus may be installed in duplicate and connected into the gas main both in series and in parallel. It is thus possible to change both the capacity of the cleaning apparatus and its intensity or thoroughness, and, what is equally important, one set of cleaning apparatus may be cut out of use for cleaning without its being necessary to shut down the plant.

It has been already stated that gas mains are sometimes made of spiral riveted pipe, but most of the pipe used in this country, especially in producer plants, is of cast iron. Wrought iron seems to be susceptible of attack by the gas, especially if the gas contains moisture.

It is the practice of some builders to deliver the engine cooling-water into the exhaust pipe, and for the reason just stated this is bad practice, whether the exhaust pipe be of cast or wrought iron.

Flanged and screwed joints and even the bell and spigot joints are all used with success and practically the matter resolves itself into which is cheapest for the size of pipe used.

Gas Valves

Gas valves vary in construction according to the requirements at the particular points at which they are introduced. When very hot gases are to be handled, such as at the blast-furnace top, at which point they are also very dirty, an ordinary bell valve, made with a flanged boiler-head, best serves the purpose. This is very cheap and efficient and the dirt collecting in it helps to keep it tight. In order that such a valve may be attached it should be located where the pipe makes a right-angled bend.

Pipes conveying comparatively clean gas are equipped with ordinary gate valves, which leave a straight run through the pipes when they are open. This is very desirable when freeing the pipes of dust, which is often done by blowing steam through them. When steam is not available compressed air is very desirable and even preferable, for it does not condense in the pipes.

When more than one engine is drawing gas from one or more sources of gas production, the size of the piping must be carefully determined so that each engine shall receive its proper quantity of gas.

While the area of the pipes leading to each engine may be exactly proportional to the amount of gas to be delivered, the lengths may be different and hence the resistance, which may cause one engine or engines to rob the others of gas.

It is far better, therefore, to make the mains leading to several engines of more than ample size.

German engineers have proposed "ring" mains for supplying several engine units and such an arrangement is very good. A main of sufficient size to serve as a small reservoir of gas runs entirely around a group of engines, the gas pipe to each engine being connected to the main at some point near the engine. Each engine, therefore, gets a liberal supply of gas, and all draw through pipes of the same resistance and against the same head.

The areas of the gas mains leading the gas and air to the engine are, near the engine, such as to give the gas and air a velocity of 20 to 25 feet per second. The products of combustion leave the engine with a terminal pressure at the exhaust valve of about 40 pounds per square inch and possess at the moment of exhaust about the same volume as the original charge before compression; consequently, the area of the exhaust pipe should be about equal to that of the inlet air and gas pipes combined, as about the same velocity is permitted in the exhaust pipes as in the feed-mains.

Curing Noisy Exhaust

The exhaust from a gas engine is noisy, as it is from a steam engine, but this can be prevented entirely if a properly designed exhaust muffler is installed. This noise commences in ordinary cylindrical pipes when the pressure of exhaust exceeds 1.7 times the atmospheric pressure.

A simple muffler which will silence the exhaust completely is afforded by the attachment of a conical exhaust funnel. Its sectional area at each point of its length should be proportional to the volume of the expanding gas at that point, in determining which the velocity of the exhaust may be safely figured the same as for steam, namely, 40 to 50 feet per second.

Commencing with an exhaust pressure of 40 pounds per square inch above atmospheric, and expanding down to atmospheric, the gases will increase in volume about ten times; consequently the exhaust main for a 500-horse-power gas engine would start at the engine with a diameter of 16 inches and gradually increase to about 50 inches. If the conical portion is at least 15 feet in length and without any bends, it will prevent all noise.

A method common to many installations is the use of a brick or concrete receiver built in the ground, having a volume about twenty times the engine-cylinder displacement.

While such mufflers are usually very effective, a riveted-steel receiver often acts as a sounding box and intensifies the noise. The exhaust piping leading from any form of muffler should be figured for the velocity stated herewith.

Another common means of muffling the exhaust is effected by the injection of either water or steam into the exhaust main. In many cases the engine jacket-water is turned into the exhaust, but this may lead to trouble with the exhaust piping, due to the formation of acids by a combination of the exhaust gases and the water. These acids rapidly eat away the pipe when they are present. The renewal of the pipe is not an extremely expensive matter, however, and the noise is effectually killed by this method.

The connections between the engine and muffler should be made up to allow of considerable expansion and contraction of the piping, due to the difference in temperatures when the engine is running and when it is not. An easy way is to mount the muffler (if of iron) on rollers and thus allow it to move bodily.

It is axiomatic that each individual installation will be a problem in itself and specific rules will hold only for general cases.

It may be well, before closing, to mention again the need of carefully avoiding the formation of dust or water pockets, or if this is unavoidable, to make them in the form of water-sealed drain-pots, so that they may be easily cleared. Moreover, these drain-pots or water-sealed connections form an admirable method of connection, since they allow of easy access and disconnection and make the system very accessible, which is absolutely essential.

Special elbows fitted with hand-holes are much preferable to ordinary elbows.

Each horse-power used for manufacturing in Pennsylvania produces annually an average of approximately $1000 worth of goods, according to a bulletin issued by the McCall Ferry Power Company.

The Manufacture of Peat-fuel in Michigan

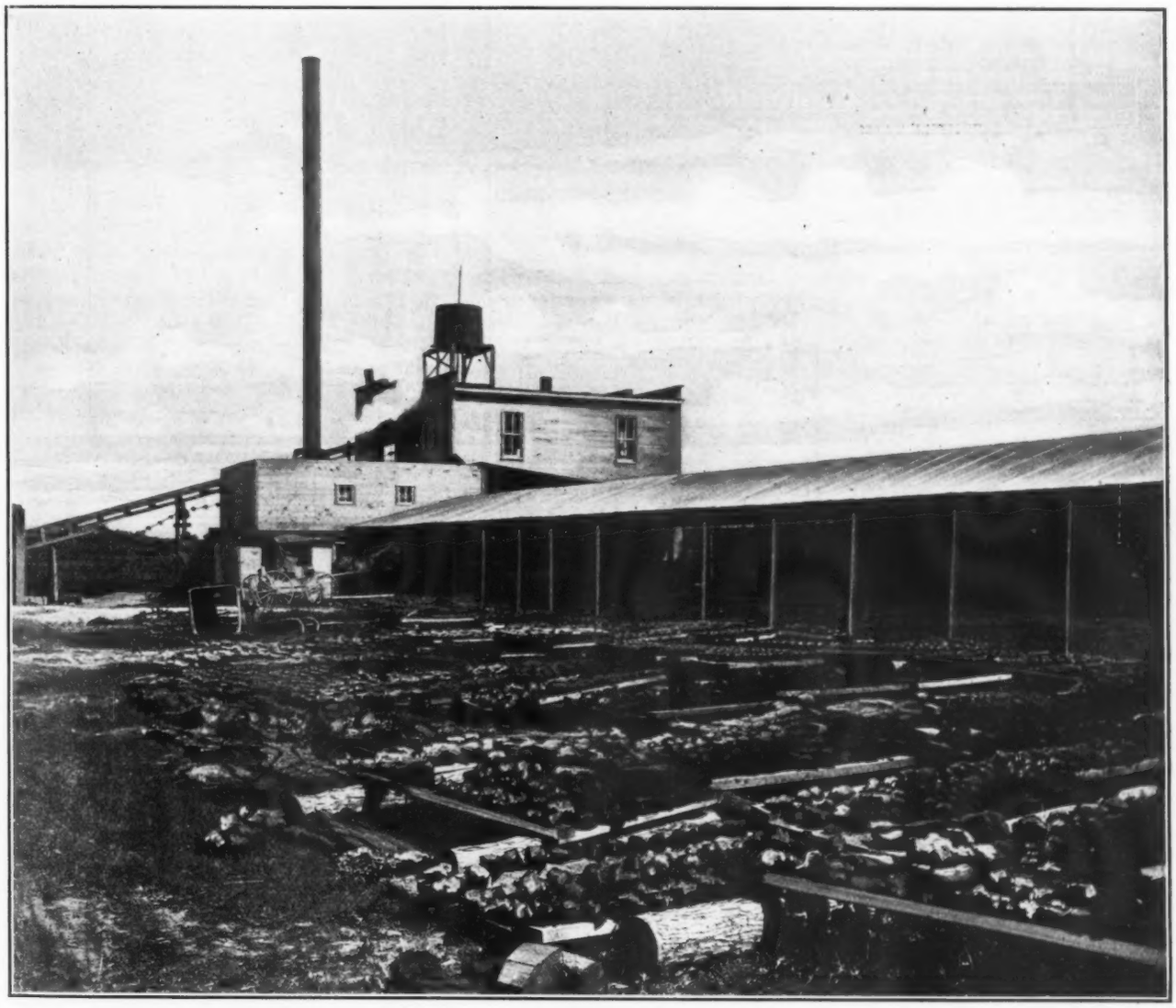
Description of the Only "Wet Process" in Use in America, from Bog to Drying Sheds, with a Brief Outline of the Industry

BY FRANCIS J. BULASK

Situated near Lambertville, Mich., on the line of the Toledo, Ann Arbor & Detroit Electric Railway Company, is the peat-fuel plant of the Commercial Artificial Fuel Company, comprising about 136 acres of bog-land, with an average depth of 10 feet, containing about 2,000,000 tons of raw material.

Governmental experiments, as well as results obtained by private investigation, having proved that the only economical and commercially profitable method to employ is that which has come into practically universal use in continental Europe, and which the writer terms the "German wet process," that process has been adopted at this plant.

The Commercial company, however, decided to discount the cheapness of foreign labor by installing labor-saving machinery. To illustrate, where it usually takes from 25 to 50 men to dig the peat by hand in German bogs, to supply the necessary raw material to the peat mill, this company installed a dipper dredge which with four men can do more and satisfactory work, while obviating the cost of draining a bog under the foreign method.



VIEW OF DRYING SHED, SHOWING PREPARED PEAT DRYING FOR FUEL

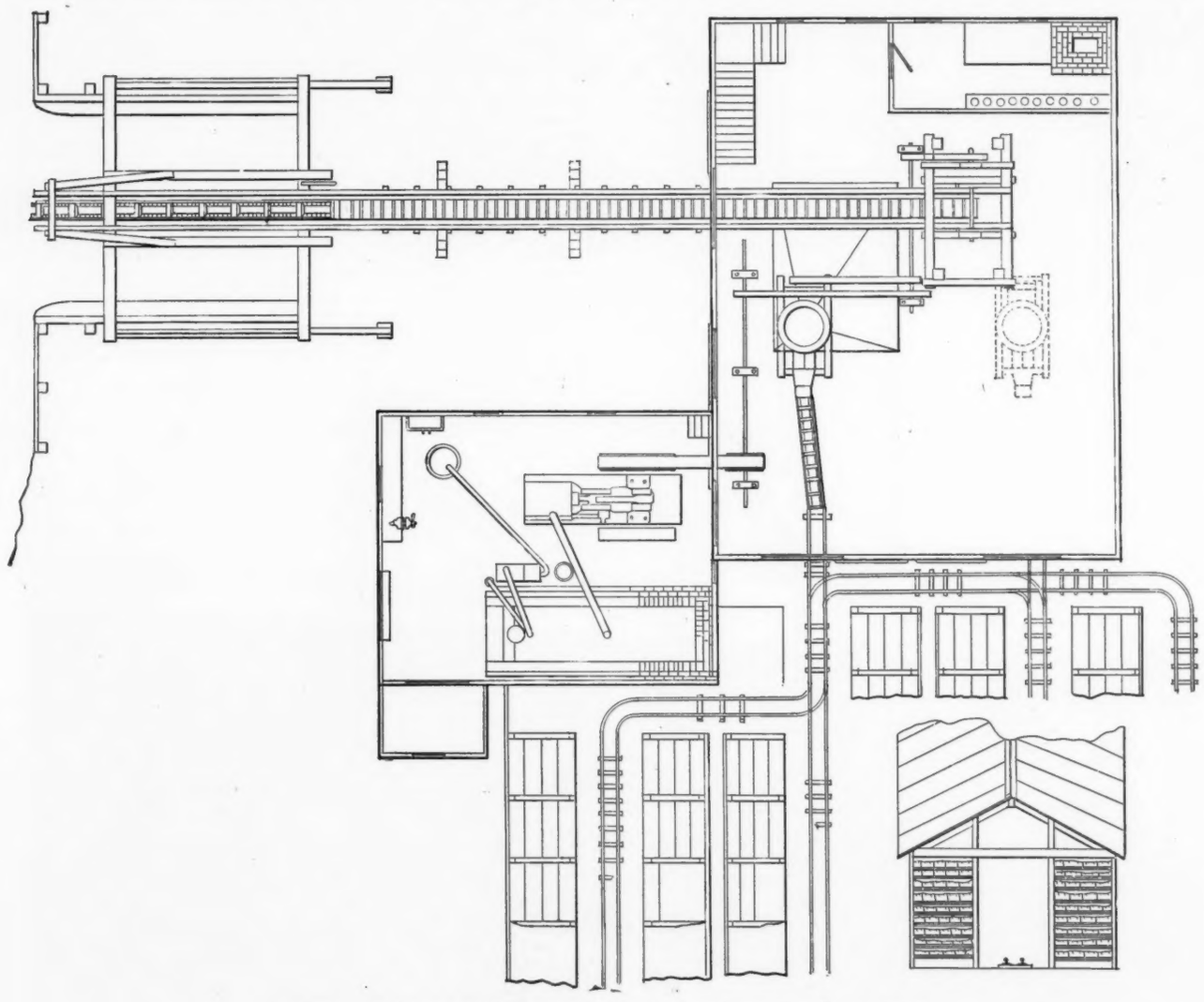
The Peat-fuel Process

The process involves the handling of the material in a wet state until it is ready for drying, instead of first draining the bog, as from 60 to 80 per cent. of moisture is necessary for the process. In excavating, the dredge dipper is drawn from the bottom upward, in order to obtain an average mixture of the strata comprising the peat-bog proper. The upper layers contain the more fibrous and the lower the more decomposed peat, both being important for fuel making. A ¾-yard dipper dredge is used and the material is

dumped into scows which are equipped with hopper tops. The scows are floated to the wharf, and the materal elevated by a bucket and scraper elevator into the second story of the building, where it drops into the hopper of a macerating or grinding mill, in which the fibrous structure is destroyed, and the more immature or partially decomposed parts undergo a chemical development, so to speak, preparing the material for the kneader, where it is thoroughly mixed.

It having been found that American peat requires more thorough maceration and kneading than the foreign product, a special machine is required, in which about 70 cutting surfaces, or knives, are assembled adjustable to the needs of the material. The machine consists of a vertical cylinder, in the periphery of which the cutting surfaces are fastened. On a vertical shaft is secured a set of sharp, shear-like blades which engage the cutting surfaces on the periphery of the cylinder. The cutting surfaces are arranged spiral fashion, so that no material that goes into the hopper can pass through to the kneading or mixing chamber without becoming disintegrated.

The kneading chamber is very similar to that used in the German plants, being composed of two revolving worms which engage each other and knead and push the material forward into the compression chamber. From the compression chamber the material is expelled on to pallets at the rate of 34 feet per minute, in the form of 4x12-inch strands, which are subdivided by knives into 4x4-inch sections, and these are cut into the desired lengths by the operator. The peat blocks are then taken in cars or trucks to the drying sheds, 16 feet wide by 12 feet high, and containing 2000 lineal feet of drying surface, in which is a rack system such as is used for drying soft brick.



OVERALL PLAN OF COMMERCIAL ARTIFICIAL FUEL COMPANY'S FACTORY

General Data

When taken out of the bog the peat is very fibrous and brown in color, but when it issues from the mill is black and greasy, and after drying it assumes a coal-like appearance, is dense and compact in structure, having lost more than half of its bulk in drying, and is as hard as tile. It has also become impervious to moisture, burning with a long flame, without smoke. It deposits neither soot nor clinkers and the ash is usually as fine as cigar ash.

Analysis of the material, furnished by the analytical department of the University of Michigan, shows that in its commercial form it contains 16.7 per cent. moisture, 55.3 volatile matter, 20.5 fixed carbon and 7.5 ash, with a heating value of 10,601 B.t.u. per pound.

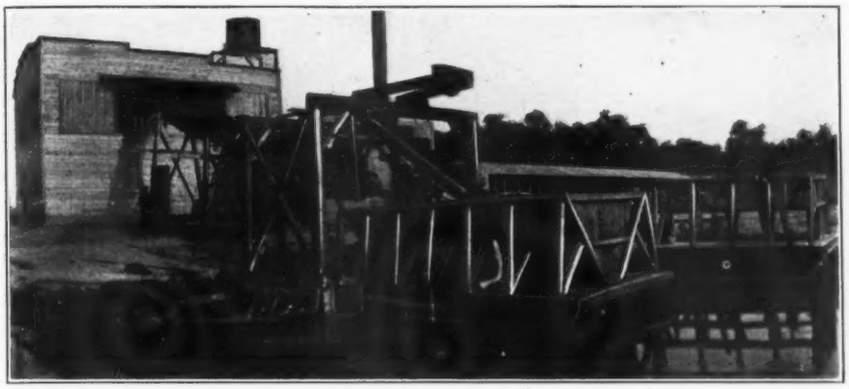
This fuel gives best results under boilers when it contains about 16 per cent. of moisture, and it burns practically without clinker, unless it has been taken out too near shore, where it becomes mixed with a very silicious sand. To use it requires no change of grate-bars or fire-box.

The capacity of the plant at present is 60 tons per day of ten hours, to be increased to 120 tons later. Although the plant is operated daily, it is incapable of supplying one-tenth of the demand.

The operations at this plant have determined that a ton of peat-coal can be manufactured in almost any locality to be sold at a profit at $3 per ton. In older countries an ever-increasing use is being found for it. Holland has used upward of one billion and a half dollars' worth of peat-fuel. The Prussian railways yearly use

500,000 tons, and the revenues received by the Czar of Russia from rentals of peat-bogs aggregate $938,000 yearly.

An extract from a Canadian Government report says: "Machine peat is sold in large quantities in Holland, Germany and Austria, Denmark, Sweden and Russia, and is used not only for domestic purposes but also in manufacturing, metallurgical and other industrial operations. A great many steam boilers, including railway locomotives, are fired with this variety of peat, while in breweries, distilleries and under salt-pans in Germany, it is preferred to other fuel. In Austrian glass-works and brick-yards it is also freely employed. Most of the peat consumed in Europe, except by the peasantry, is machine peat, and it forms in fact the only fuel for many large bodies of population."



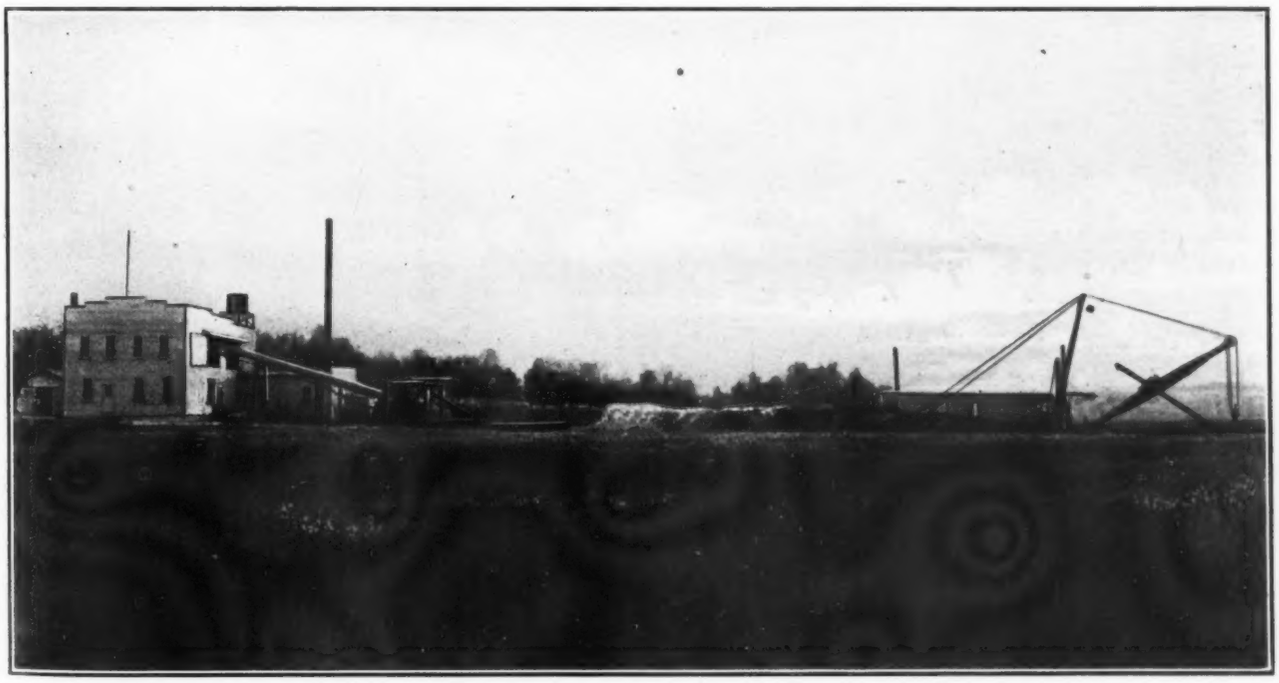
PEAT-FUEL FACTORY, SHOWING SCOWS AT WHARF

The "Story of Peat"

Many experiments have been made in the United States and Canada during the last five years to convert raw peat into a marketable fuel. After thoroughly investigating European methods the writer concluded that whereas foreigners built their machinery to accommodate itself to the peculiarities of the material, Americans had accommodated the material to their conception of machinery, without going to the trouble of studying older methods, and this led to the erection of a number of costly experimental plants. In one instance large concrete buildings were erected and expensive machines, including "oscillating dryers" and "hydraulic presses," were installed. It was later found that the bog upon which the plant was located did not contain material fit for fuel. This, of course, could have been learned beforehand. The experts in the meantime learned that to employ such methods would consume two pounds of dried fuel in order to drive the moisture out of one pound of wet, and also that the so-called "briquettes" disintegrated while burning, and lost several thousand B.t.u. in the drying process. It is stated that it cost upward of $200,000 to ascertain that an economical peat-coal could not be manufactured by artificial drying and hydraulic pressure.

A more conservative firm took the precaution first to send a representative to Europe to report on the most advanced methods employed there. Unfortunately, this represntative became enamored of a so-called electrical process, of which much had been written, and reports were current that a plant was in successful operation in Europe, which turned out marketable peat from the bog to the railway car in two hours. It took an investment of about $150,000 in this country to prove it a fallacy. The writer will admit that upon first reading of this wonderful electrical process he, too, was smitten with its possibilities, but he and his associates were forewarned, and therefore forearmed.

Recently a graduate of one of the leading technical schools of the country, who has spent some years in the study of peat for fuel purposes, made the following statement: "Of all the refractory propositions I ever went up against this is the limit. Show me a machine which looks plausible and I am certain that it is no good." Therefore, there is some excuse for the daringly speculative, quick-and-easy money-making American, who too often takes things for granted when promised wonderful returns for his investment. No other explanation is sufficient to explain why such a number of failures have been recorded in this industry, so well understood in all foreign peat-coal producing countries.



GENERAL VIEW OF PEAT-FUEL PLANT, DREDGE AND BOG

Improvements in the Vertical-plunger Sinking Pump

By A. H. Hale

The vertical-plunger sinking pump suspended in a shaft by means of a wire cable and hangers that hook onto the shaft timbers is in almost universal use where deep shafts are being sunk, having supplanted the old-time Cornish pump.

It is undoubtedly true that the type of pump under consideration is very wasteful of steam, due in a certain extent to the simple valve motion, which is considered best for a pump working under the conditions a sinking pump is compelled to work under.

It has been learned from experience that so far as a sinking pump is concerned it is best to sacrifice economy to simplicity. The simple valve-gear, consisting of only four moving parts, all within the steam chest and steam cylinder, may be wasteful of steam, yet it possesses the great merit of operating under 50 feet of water as well as though the pump were just above the surface. It is not unusual, when sinking a shaft, for the water to rush in and submerge the pump, or "drown it."

Frequently, also, sinking pumps have to work 2000 feet away from the boilers that supply them with steam. A very large percentage of the waste of steam the pump is blamed for could be avoided by the use of a separator in the steam line near the pump, and by insulating the steam line so as to prevent condensation. Likewise, a steam separator at the boiler is of value, as much of the water supposed to come from condensation in the steam line is water carried over by the steam.

One serious defect or fault in the design of sinking pumps, which the builders are alone to blame for, is the design of the water-valve chest. As shown in my design, Fig. 1, there is no reason why hinged bolts should not be used about the chest, nor why the bonnet or cover should not be hinged also. In this way the time required to examine the valves—something which has to be done quite often—is greatly reduced. The bonnets on some makes of 14 and 7 by 13-inch sinking pumps weigh about 75 pounds, and on the larger sizes upward of 150 pounds—rather awkward pieces to handle in a wet shaft.

Another great annoyance where stationary bolts are used is caused by the nuts getting changed about and requiring to be turned up with a wrench the entire length of the thread. I notice that one builder of sinking pumps has finally decided to have part of the chest bolts hinged, the remainder being stud-bolts. This combination makes anything but a neat design, but it goes to prove that the

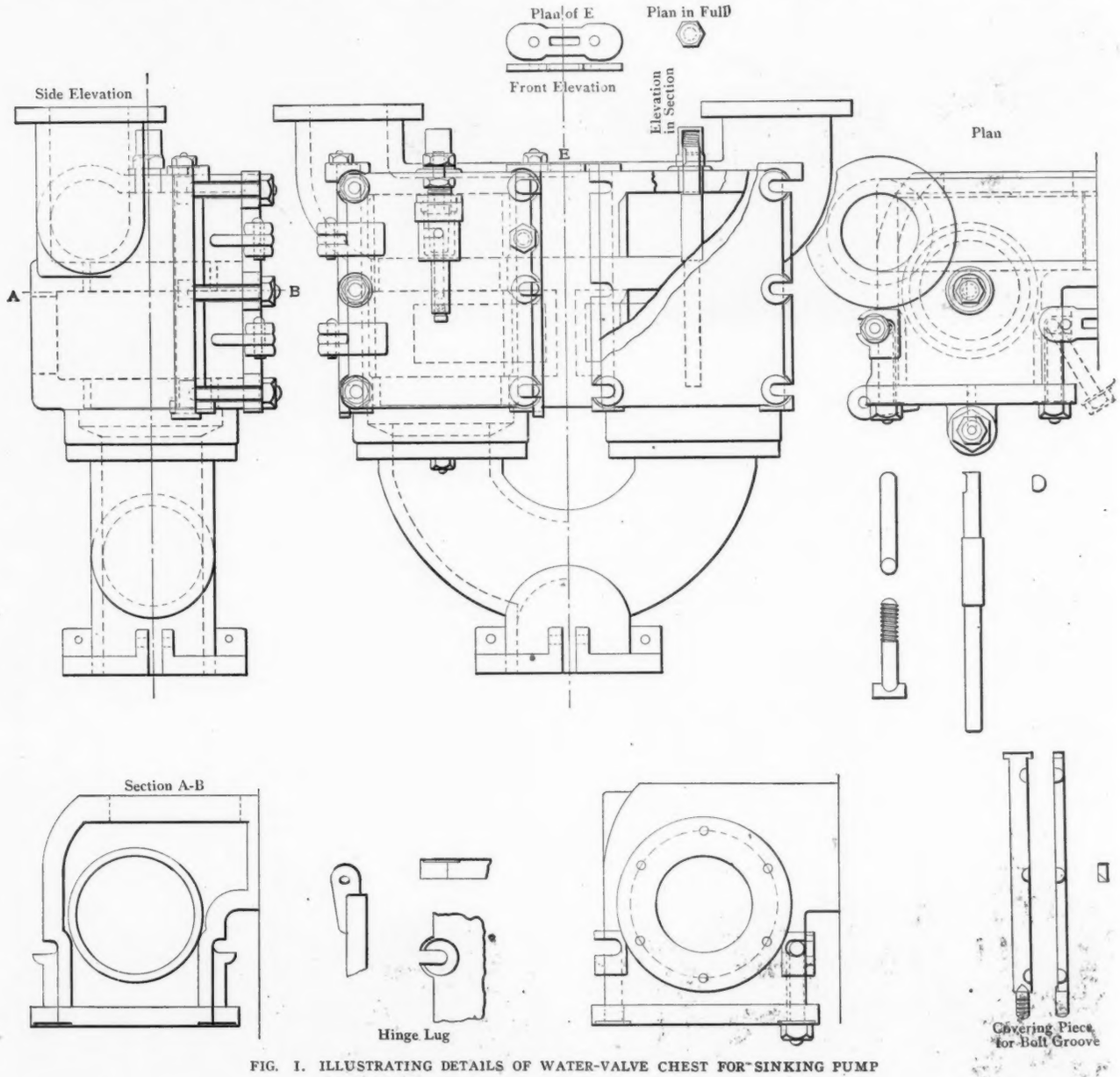


FIG. 1. ILLUSTRATING DETAILS OF WATER-VALVE CHEST FOR SINKING PUMP

builders consider hinged bolts better, or they would not have substituted them for stud-bolts.

A still further change I would advise is in the cap-nut that keeps the water-valve stem in place. As now made it consists of a cap-nut with a set-screw in the top. The squares on the cap-nut are of no particular size as compared to the other nuts on the bolts of the water chest, and the small set-screw in the cap-nut is very often bent or broken. In fact, it is rarely otherwise after the pump has been in service a short time. With the design I show in Fig. 2, the valve-stem and cap are practically one and I avoid the use of the set-screw, while the nut on my design is of the same size as the other nuts about the water end.

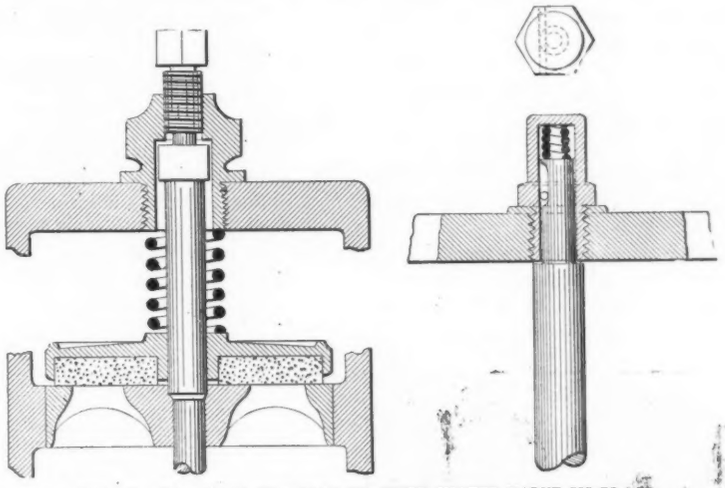
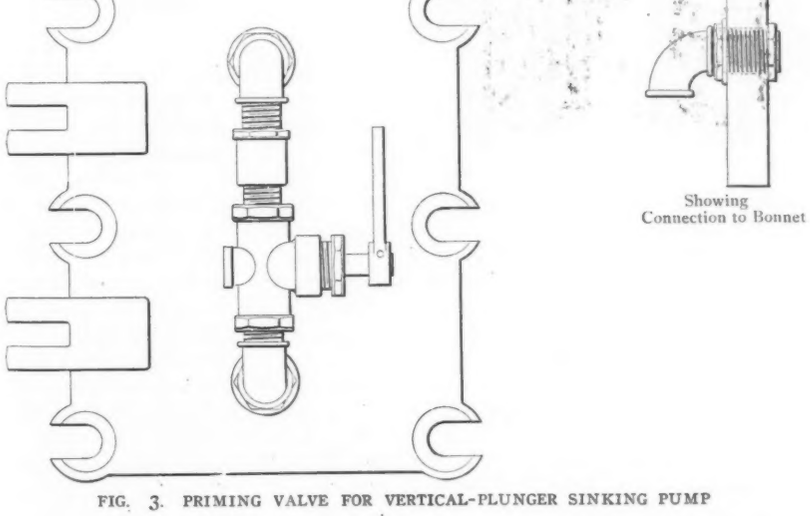


FIG. 2. SHOWING CAP-NUT TO KEEP WATER VALVE IN PLACE

A priming device of some sort is really indispensable about a sinking pump. One of the best arrangements I know of for the purpose is to connect the discharge-valve chest with the suction-valve chest by means of suitable passages or piping having a valve of some sort. Such a device has been in use for many years on pumps in the mines in the West. I know it has been in use for more than twenty years and possibly longer. Yet in face of this fact a certain builder of sinking pumps claims to hold a patent on the device. For a stop-valve between the two chests, the builder referred to uses an angle-valve. A valve of that kind is utterly worthless for the purpose. They are of such light design that they are soon put out of service by the rocks thrown by the blasts. And as the men in charge of the pumps are usually unskilled and are not familiar with their construction or operation, a plug-cock is much more easily understood by them. They can always tell by the mark on the end of the plug when the valve is open or closed, and there is no chance of their twisting the stem off, as is often done when attempting to operate an angle-valve or a globe valve.

The plug-cock I have shown in Fig. 3 has a nut on the end of the stem for turning the plug; this nut is the same size as the others about the chest.



Showing Connection to Bonnet

FIG. 3. PRIMING VALVE FOR VERTICAL-PLUNGER SINKING PUMP

I also submit a sketch (see Fig. 3) of what I am inclined to think was among the first of the priming devices for sinking pumps. It is very simple and cheap and I believe it to be fully as good as, if not better than, the other designs I have referred to.

In case the plug-cock gets to leaking it can be replaced at a trifling cost in a few minutes. I do not advise tapping the chest bonnet for the connection, as in the event of the nipple breaking off it requires some little time to cut out the piece in the hole. I believe that making the connection to the bonnet by means of a running sleeve and back-nuts is the best method. A running sleeve between the cock and the elbow, as shown, will save quite a little trouble in getting the exact length so that the ends will enter the holes in the bonnet.

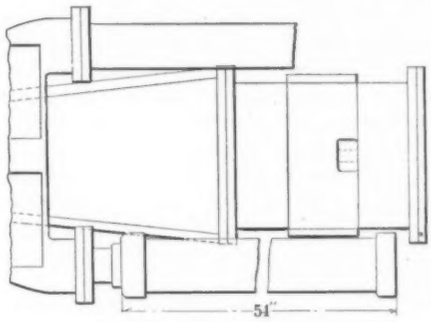


FIG. 4. AIR CHAMBER

The same builders who claim a patent on the 20- or 30-year-old priming device also claim to hold a patent on an air chamber, in which the discharge pipe connects at the top of and passes down into the chamber for some distance, the annular space between the discharge pipe and the walls of the chamber acting as a receiver for the air. This type of chamber is old; it was used at one time by a firm of locomotive builders; the design never became popular with builders of any line of pumps. In fact, the design is absolutely without merit. An air chamber must be of a certain size, that is, it must have a certain air capacity relative to the discharge of the pump. A perfect pump would not require an air chamber.

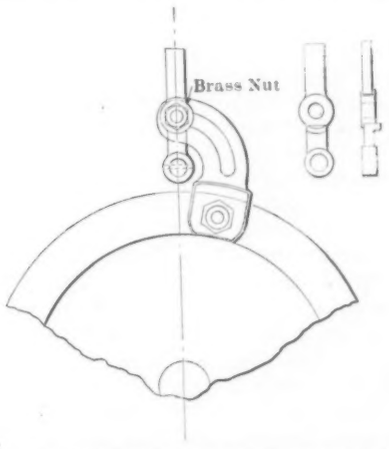


FIG. 5. QUADRANT AND LEVER OF CUSHION VALVE

The best air chamber for a sinking pump is one made of wrought-iron pipe,

as shown in Fig. 4. This design takes up less space in the shaft and is less likely to leak air than cast iron.

A tap-bolt, or bolts, should always be put in the bonnets so the joints may be broken without the use of a hammer and chisel. A coating of graphite on the face of the joint will prevent sticking and damage to gaskets. Chalk is about as good as graphite for the purpose.

I have shown the branch pipe, Fig. 1, connecting the suction pipe to the chest as a separate casting. It could be cast with the chest. If it is, provision must be made for the passing of the boring bar through the branch pipe, and instead of the plate *E*, lugs could be used, as shown on the outside top corners of the chest.

It is best to have all nuts that are liable to require adjusting from time to time of the same size, so that only one wrench will be necessary. This may require at times a bolt somewhat out of proportion, but the benefits gained by having all nuts of the same size will offset that small defect in the design.

I have found the cushion-valve quadrant and lever to be poorly adapted for the purpose intended. The pieces mentioned are sufficiently strong for pumps working under normal conditions, but they are too light to withstand the rough usage they receive in a mine shaft. I have designed one which I know will stand hard usage, see Fig. 5. I use a ¾-inch nut and bolt in the quadrant for locking the lever. No doubt a ½-inch bolt would be strong enough. I did not care to use a lever, or "tailboard" nut, as it is a common practice to set them up with a hammer of some sort.

Boiler Test

The following results were obtained by the Robert W. Hunt Company, of Chicago, in testing the boiler of Milwaukee District School No. 1, on May 1, 1907:

Kind of boiler—Return-tubular.

Kind of grate—Hawley down-draft.

Dimensions—16 feet long by 60 inches diameter.

Duration of trial—9 hours.

Stack—83 feet high, 34x34 square feet area.

Grate surface—Lower grate, 23 square feet; upper grate, 23 square feet; total, 46 square feet.

Water heating surface—880 square feet.

Ratio of grate to heating surface—1 to 19.

Average pressures:

- Barometer—29.58 inches.
- Steam gage—14.00 pounds.
- Draft gage—0.3 inch.

Average temperatures:

- External air—47.2 degrees F.
- Boiler room—65.5 degrees F.
- Steam corresponding to pressure—248 degrees F.
- Escaping gases—487 degrees F.
- Feed-water—50.7 degrees F.

Fuel:

- Kind of coal—Youghiogheny mine screenings.
- Cost per ton—$2.92.
- Total fuel used—2499 pounds.
- Per cent. moisture—1.21.
- Dry coal—2468 pounds.
- Total ash—292 pounds.
- Per cent. ash—11.4.
- Total combustible—2176 pounds.

Dry fuel per hour:

- Coal per hour—274.22 pounds.
- Combustible per hour—241.8 pounds.
- Coal, per square foot of grate, per hour—5.96 pounds.
- Combustible, per square foot of grate, per hour—5.25 pounds.
- Coal, per square foot of heating surface, per hour—0.312 pound.

CURIOUSLY REGULAR GAGE-GLASS FRACTURE

- Combustible, per square feet of heating surface, per hour, 0.275 pound.
- Coal per horse-power—3.153 pounds.

Water:

- Total water—22,898 pounds.
- Factor of evaporation—1.179.
- Total from and at 212 degrees F.—26,997 pounds.
- Quality of steam—Dry.

Water per hour:

- Amount used—2544.2 pounds.
- Evaporated from and at 212 degrees F.—2999.6 pounds.

Evaporation:

- Actual evaporation per pound of dry fuel—9.27 pounds.
- From and at 212 degrees F.—10.83 pounds.
- Actual evaporation per pound of combustible—10.52 pounds.
- From and at 212 degrees F.—12.40 pounds.
- Actual evaporation per square foot of grate surface, per hour—55.30 pounds.
- From and at 212 degrees F.—65.20 pounds.
- Actual evaporation per square foot of heating surface, per hour—2.89 pounds.
- From and at 212 degrees F.—3.41 pounds.

Horse-power:

- On basis of 34½ pounds per hour, from and at 212 degrees F.—86.94.
- Builder's rating—88.00.
- Ratio of commercial to builder's rating—1 to 0.988.
- Heat generated per hour, B.t.u.—3,641,093.
- Heat absorbed per hour, B.t.u.—2,867,930.
- Efficiency of boiler, per cent.—78.76.

Cost of evaporating water:

- Cost of evaporating 1000 pounds of feed-water—0.1582.
- Cost of evaporating 1000 pounds of water from and at 212 degrees F.—0.1352.
- Cost of 10 boiler horse-power, for 10 hours—0.4664.

Coal Analysis:

- Moisture—1.21 per cent.
- Volatile matter—34.80 per cent.
- Fixed carbon—53.58 per cent.
- Ash—10.41 per cent.
- British thermal units, per pound of dry coal—13,278.

A Curiously Regular Gage-glass Fracture

We have received from I. Sewell, chief engineer of the Washoe Smelter at Anaconda, Mont., the fragment of a gage glass which is illustrated herewith. It is a "Durax" glass of the ordinary diameter of an inch, the length not being given, and broke under a pressure of 160 pounds. This spiral fracture is not uncommonly met with, but we had never seen a specimen in which it was so regular and so curiously disposed, being at right angles to the axis of the glass upon one side, and these fractures being connected by inclined lines, practically parallel with each other, upon the other side of the glass. Why this line should flatten out upon one side instead of following helically around the glass is an interesting study. The fine stripe down the back of the glass upon the side where the lines of fracture cross at right angles is offset about its own width between each fracture, showing that there was an internal torsional strain in the glass which was relieved by the fracture.

Best Method of Supplying Oil to Turbines

The Isolated Oil-filtering and Cooling Plant; Its Advantages and Points to Be Looked to in Its Design and Operation

BY THOMAS FRANKLIN

For a large turbine installation consisting of several units it is preferable to have a separate oil-supplying and cooling plant, located in a different building, to feed all the turbines from one source, rather than to make each turbine perform its own oil circulation by means of an attached pump, cooler, etc. Each of these methods has its peculiar advantages, of course, but it almost goes without saying that in the long run the former will prove immeasurably superior in regard to maintenance. In this article, it is proposed to describe somewhat briefly a large oil plant in England, which has been working very successfully for some time, and then to show where the possibilities of oil loss in a turbine installation lie.

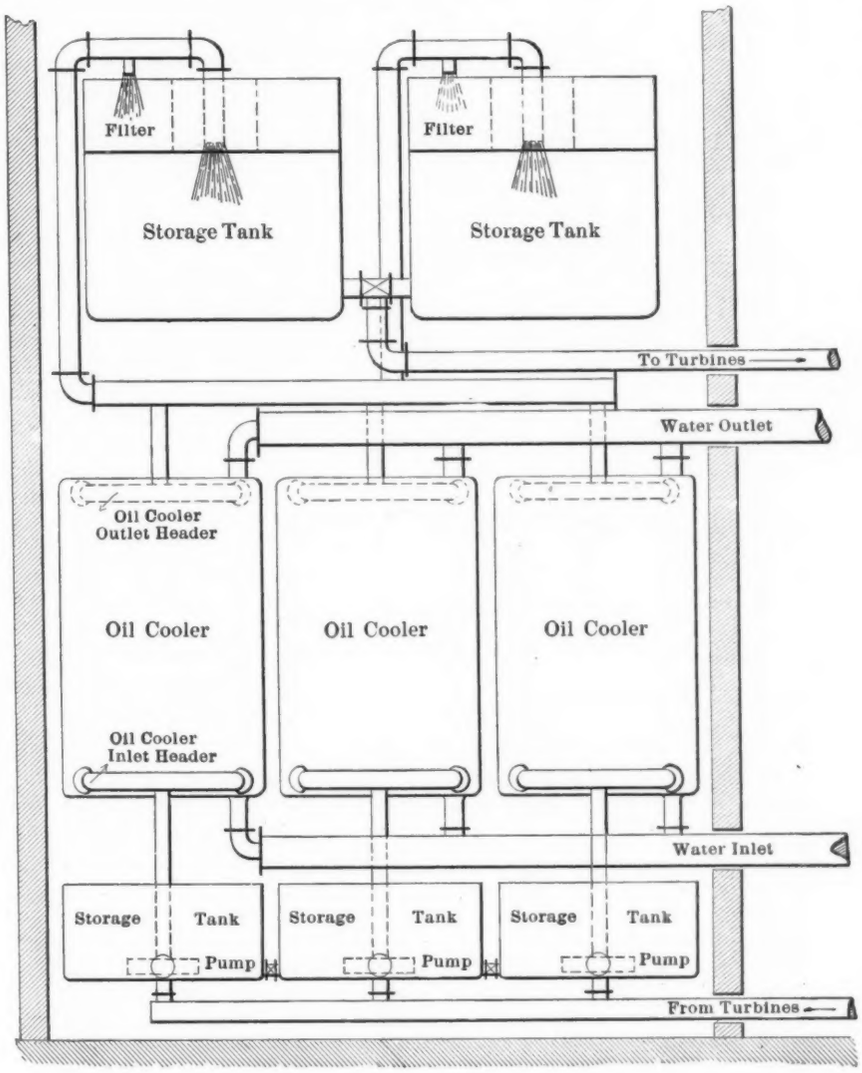


FIG. 1. ELEVATION OF OIL-HOUSE PLANT

Fig. 1 shows an elevation of the complete oil-house plant. The oil having returned from the machine enters the storage tanks in the basement, whence it is forced by pumps through the oil cooler to the top floor and into the upper storage tanks, about 5 per cent. of the circulating oil passing through the filters. A supplementary water-supply, not shown, was provided for emergency.

The question of the quantity of cooling water for any specified amount of oil-cooling surface is of considerable importance, and means should be adopted to permit the normal volume of water to be considerably increased when required. In large turbine plants abnormal conditions are more or less constantly cropping up, and it is then that the value of the possibilities of the plant to cope with such circumstances are revealed. At a large station the oil circulating through the turbines was reduced to a dangerous minimum, owing to the breakdown of two oil-pump motors. It was found necessary to change the motors, and while this was being done the temperature of the oil gradually rose until it attained a really dangerous point. It was possible to double the amount of oil-cooling water, which was immediately done, and this had the desired effect, the temperature of the oil at the turbine bearings falling slightly and remaining down until an oil pump could be re-started.

Fig. 2 is a section through the oil filter. This type of filter possesses several very advantageous features and requires little or no looking after. The oil enters at the top, as shown, and falls through the oil strainer *S* into the first compartment. A baffle plate *B* directs the passage of the oil to the first oil pipe, down which all entering oil flows. The bottom of the filter, except the final compartment, is covered by water to a depth of six inches, or maybe a foot, and floating on the water in each division is a filtering medium of wood wool, or its substitute, which fills the rest of the space up to the perforated plates *P P*. The oil thus has to rise through a water bath and a filtering substance in each chamber before being delivered into the next. The final chamber contains filtered oil only. Air-vent pipes branch out of each oil pipe.

It has been stated that the presence of water in this form of filter is conducive to its accumulation in the circulating oil, and there would appear to be some ground for this. It is not improbable that particles of water are carried up with the cool and comparatively viscous oil and ultimately delivered into the mains. Even if this were the case, the percentage of water is very small and it would be again precipitated in the hot storage tanks, before the oil enters the coolers, from which it can easily be drawn off.

With a large filter of the above type it is often the practice to split up the body longitudinally and transversely, as shown in the lower part of Fig. 2. This plan admits of a greater working efficiency and

also facilitates cleaning, the initial stages naturally requiring attention at shorter intervals than the final ones.

Water in an Oiling System

The accumulation of water in an oil system, particularly in large plants that have a long and intricate range of oil mains and headers, is sometimes considerable, and its prevention difficult. Large turbine bearings are often water-cooled, the water flowing through the hollow body of the bearings. In such cases the bearing halves are cast hollow, the necessary core holes usually being plugged up afterward. A pressure test is always made previous to assembling, to assure the tightness of these plugs. As this test is usually made when the bearing is cold, however, it does not necessarily follow that sound plug joints can be relied upon when the temperature of the bearing body has reached, say, 140 degrees Fahrenheit. As a matter of fact, a number of large bearings, perfectly water-tight when cold, were found to leak considerably at the plugs after running a few months. This leakage was only discovered after much trouble and time had been spent in trying to find the cause of the abnormal percentage of water in the oil.

As most large turbine bearings are on the spherical order and are capable of alining themselves to the turbine spindle, the pipes introducing the cooling water to, say, the bottom half of a bearing (it seldom being necessary to cool the top half) must possess a certain amount of flexibility. Fig. 3 illustrates a water-cooled bearing bottom half, in elevation and plan, and reveals at once the point at which it is possible for water to leak into the bearing cover, which contains the oil after it has left the bearing. This point is where the inlet water pipe enters the bearing. An ordinary gland is usually insufficient to guarantee absolute freedom from leakage, and a rubber or other soft washer, tightened up between the pipe flange and the bearing, is more likely to insure a good joint, should any transverse strain be placed upon the pipe.

At the oil cooler the amount and direction of leakage depend upon the existing conditions. For instance, if the pressure of the circulating water surrounding the cooler oil pipes be greater than that of the oil inside the pipes, a leaking pipe would allow a constant flow of water into the oil system, and any unduly large accumulation might safely be attributed to such a cause under these conditions. On the other hand, should the water pressure in the cooler be less than that of the oil, the leakage would be in the opposite direction. The question then arises as to whether it is desirable to maintain the oil pressure higher than that of the circulating water (which method positively prevents water entering the oil pipe), and a consequent necessarily strict and continual examination of the cooler outlet water, or to regulate the water pressure to a point above that of the oil. In oil plants constructed on the gravity system a considerable oil pressure is often recorded, and there are very obvious objections to the maintenance of a high water pressure under any conditions. This being so, it would appear preferable to maintain an excess of oil pressure, and, as before stated, make a periodical analysis of the cooler water.

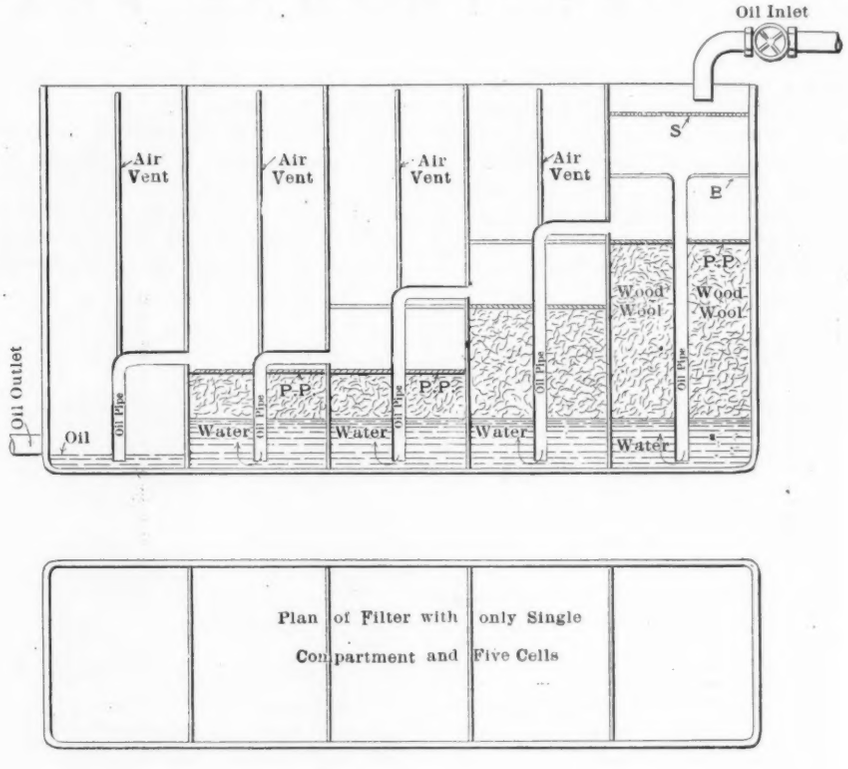


FIG. 2. SECTIONAL ELEVATION AND PLANS OF OIL FILTERS

Choice of Pumps and Method of Driving

The choice of oil and water pumps and the methods of driving them form another point which can only be advantageously decided upon when the conditions are known. For example, in a large electrical supply station possessing a separate oil house, it is obviously the correct thing to install electrically driven pumps, either centrifugal or force. The former has been found to give highly satisfactory results both when pumping oil and water. One cannot, however, be too careful in dealing with such matters, and it is sometimes found that owing to complex conditions, it might be desirable to install one type of pump for the oil and a totally different type for the water. Where, for instance, the oil-cooling water runs from a river and perhaps carries with it a quan-

tity of air, the centrifugal pump is somewhat at a disadvantage, as cavitation and other characteristic troubles are likely to ensue, just as in the case of centrifugal condenser circulating water pumps. A motor-driven plunger pump in such a case

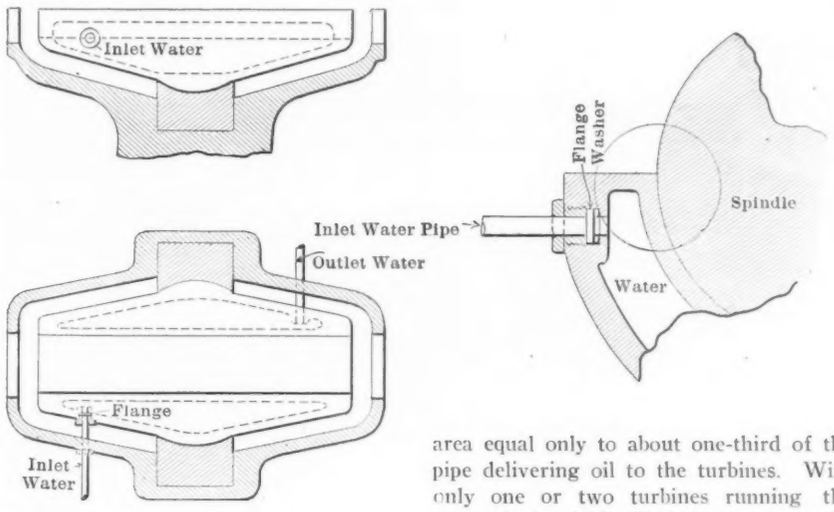


FIG. 3. ELEVATION AND PLAN OF A WATER-COOLED BEARING, BOTTOM HALF

would probably act in a more reliable manner and be of relatively greater value, especially where (as for turbine oil coolers) continuity of water supply is desired.

The writer was present at a recent expert examination of the oil plant of a power station, which had not fulfilled expectations. It was stated that the oil pumps (steam-driven plunger type) were of insufficient pumping capacity, and in addition the oil pressure at the turbines fluctuated to an enormous extent. The general design of this oil plant did not greatly differ in principle from that shown in Fig. 2. The top storage tanks were inclosed, being simply cylindrical vessels with an overflow pipe from the top delivering into the bottom tanks. The expert conducting this test in the first place filled the top oil tanks (the capacity of which was known) and then, with no pumps running, took oil consumptions over varying periods. This was accomplished by cutting the oil down to a minimum at the turbine valves, and noting by means of a graduated gage glass on the oil tanks the total consumption per unit time, from which was calculated the consumption per turbine. The total oil consumption was found to be much below the specified capacity of the pumps, and so attention was next turned to the pumps themselves.

The dismantling of these revealed a unique practice. The flat-seated valves had been specified and made of rubber, and, of course, had almost entirely crumbled away, consequent upon the action of the oil. These valves were replaced by metal ones, and the volume of oil delivered by the pump trebled. This was not all, however. The pressure of oil at the turbine continued to mysteriously fluctuate, being excessively high when only a portion of the units were in operation. Further investigation showed the previously mentioned overflow pipe from the oil storage tanks to be of a sectional area equal only to about one-third of the pipe delivering oil to the turbines. With only one or two turbines running the pumps had quickly filled the storage tanks and set up considerable pressure therein, owing to the comparatively small overflow pipe being unable to carry off the surplus oil with sufficient rapidity. This overflow pipe was replaced by one equal in diameter to the delivery, and no further trouble was experienced.

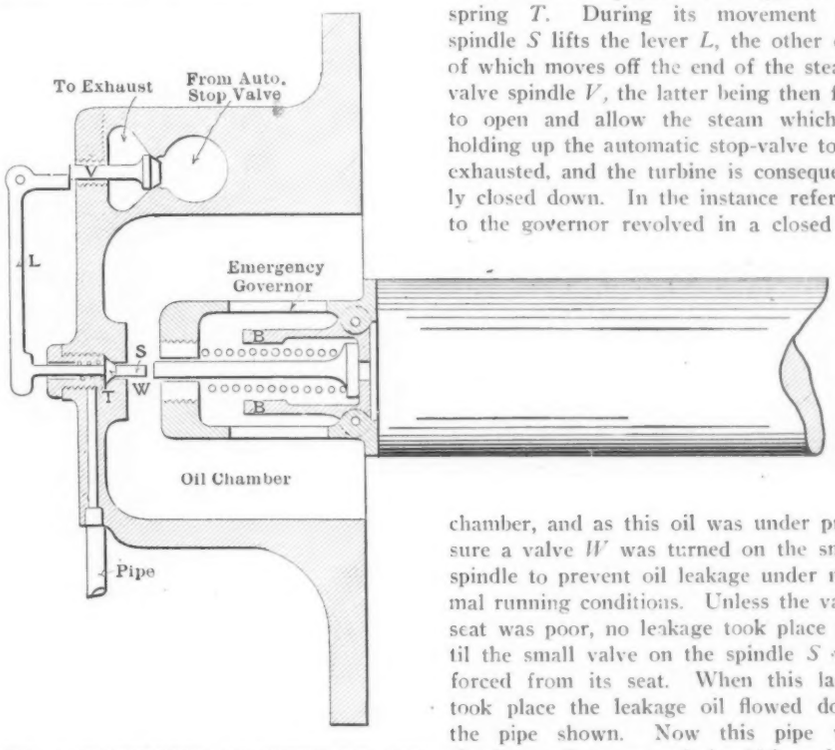


FIG. 4. ILLUSTRATING AN INTERESTING CASE OF OIL LOSS

A Perfectly "Tight" Plant Essential

The maintaining of a perfectly "tight" oil plant, particularly in a separate oil system constructed on the gravity or other principle, is admittedly a question of vital importance, inasmuch as any direct loss increases the running cost. It is not as simple a matter as one would think to prevent leakage and loss of oil in very large and sometimes intricate installations circulating, say, from 5000 to 15,000 gallons of oil. Where, then, are the most likely points of leakage situated? It would be ridiculous to assert anything positive in this relation, the question of the individuality of plants again having to be taken into account. Thus, one make of turbine, or even only one turbine of a particular class, might, owing to a fundamental or structural weakness, be attended with excessive oil leakage along the revolving spindle and out at the bearing ends, which in a different design may be found to have been entirely eliminated. It is perhaps hardly necessary to say that all oil mains and headers in any system of oil supply should invariably be exposed to easy and complete view.

An interesting case of oil loss recently pointed out was due in a measure to carelessness on the part of an erecting engineer, and the somewhat similar negligence of the designers. Fig. 4 illustrates this. The emergency governor is bolted on to the turbine spindle end. When the speed of the turbine rises a certain percentage above the normal, the bell-crank governor-ball arms *B* force the spindle out. The end of the spindle eventually comes into contact with the small spindle *S*, which is also pushed out against the spring *T*. During its movement the spindle *S* lifts the lever *L*, the other end of which moves off the end of the steam-valve spindle *V*, the latter being then free to open and allow the steam which is holding up the automatic stop-valve to be exhausted, and the turbine is consequently closed down. In the instance referred to the governor revolved in a closed oil chamber, and as this oil was under pressure a valve *W* was turned on the small spindle to prevent oil leakage under normal running conditions. Unless the valve seat was poor, no leakage took place until the small valve on the spindle *S* was forced from its seat. When this latter took place the leakage oil flowed down the pipe shown. Now this pipe was simply an oil return and should have been connected to the oil-return header; but the erecting engineer, thinking no doubt that there would never be any flow of oil through it, except on those occasions when the turbine "ran away" and automatically shut itself down, connected the pipe to an exhaust-steam drain.

Unluckily the small spring *T* was care-

lessly left out when the valve was assembled, and as no definite instructions or drawings describing the method of connecting up the oil pipes had been received, the mistake was made. Of course, when the turbines were running the valve was held hard down on the seat by the lever *L*, but each time the machine was shut down (and the shutting down was invariably performed by pulling out the lever *L*, thus allowing the automatic stop-valve to fall), a constant flow of oil took place down the pipe. As a matter of fact, the springs had been left out of several of the turbines and the loss of oil in one month from this cause alone amounted to several hundred gallons. Even after the springs had been placed on the spindles, a slight leakage continued to take place, owing to the comparative weakness of the springs, and the oil pressure inside the oil chamber. The well-known proneness of oil to percolate through even the tightest joint or valve seat necessitates the connecting of all possible outlets to the return pipes, and this course should always be adopted. Where, as in some special cases a good deal of condensed steam or other alien matter is constantly flowing into the oil drains, it is advisable to have a separate system of drain mains leading into a filter or tank in the oil house. The oil thus collected can be filtered for further use, or might be advantageously used for other purposes without any filtering whatever. A complete oil-drainage system, collecting the otherwise lost oil from circulating pumps, air pumps and all the auxiliary plant, in addition to the small amount from the prime movers themselves, is undoubtedly a valuable asset, and will quickly repay its initial cost in saving.

Saving Exhaust Steam from an Intermittently Running Engine

Everyone who has passed by a steel mill has noticed the large volumes of steam exhausted intermittently by the engine driving the rolls. This is a powerful machine, and its great output of energy is expended during the few moments while the bloom passes through the rolls. In a three-high mill, where the material is passed first above and then below the middle roll, the engine always runs in one direction, but with some mills it must reverse after every pass. The sound of this operation, the heavy, rapidly-increasing puff-puff-puff of a 6000-horse-power engine, the rumble and crash of the rolls, then the momentary lull and repetition, have strongly impressed everyone who has ever been near a steel mill.

So large an engine exhausting to the atmosphere can hardly fail to set a steam engineer thinking upon the waste of water and heat indicated by the white clouds of steam. Still, upon second thought, to save this heat and steam is not so easy. The delivery is so intermittent and violent that it would be impracticable or impossible to handle it in a condenser, even were the circulating water at hand to condense it. Further, the manner of handling the engine and the shortness of its periods of activity would not tend to render a condenser economical. The exhaust cannot be turned into any heating or other apparatus, where it would be obstructed in its free escape and where back-pressure would be created.

It is true that there is plenty of work for it in pre-heating feed-water for the boilers, but feed-water heaters as ordinarily installed must have both steam and water delivered uniformly together. If the water is fed steadily, the steam must come steadily. If the steam comes in rushes for short periods, it will be wasted if there is not a similar increase of the water supply. Again, if the water is fed while there is no steam, it is not heated and so lowers the temperature of the whole mass of water in the heater settling chamber that one of the chief advantages of an open heater, the precipitation of scale-forming matter, is lost.

The accompanying illustrations show how this saving was effected by the Harrison Safety Boiler Works, in a well-known steel mill, where a 6000-horse-power reversing engine is used to drive blooming-mill rolls. The time occupied by the longest "pass" and, therefore, the period during which steam would be delivered by the engine, was found to be about three minutes, and between the passes there were intervals when no steam would be exhausted, sometimes longer than three minutes. The admission of steam to the blooming-mill engines is controlled by a man in the "pulpit," a platform overlooking the rolls, where there is a lever connecting with the valve-gear of the engine. So, in order to admit cold water to the heater during the periods when exhaust steam would be available, a connection was made from this lever to the water admission valve of

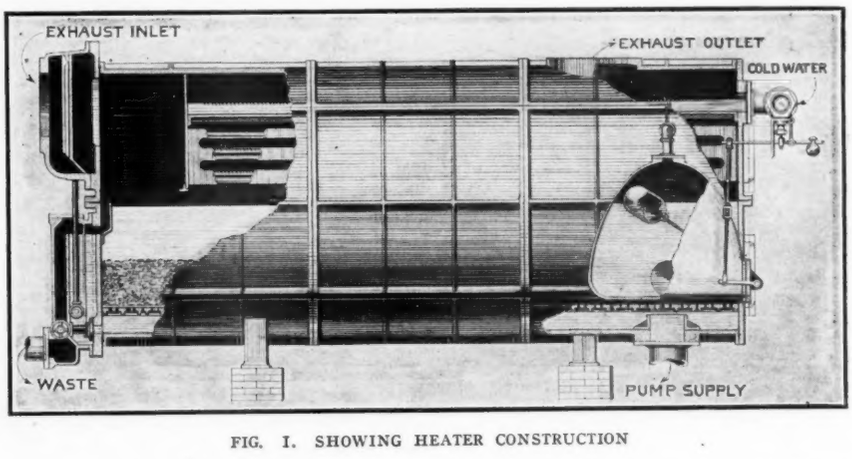


FIG. 1. SHOWING HEATER CONSTRUCTION

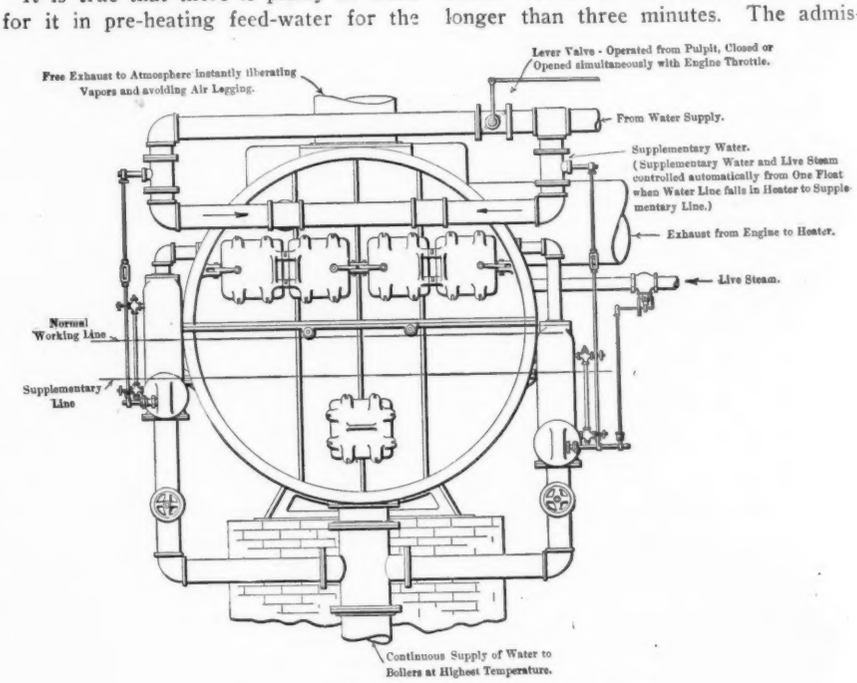

Free Exhaust to Atmosphere instantly liberating Vapors and avoiding Air Logging.
Lever Valve - Operated from Pulpit, Closed or Opened simultaneously with Engine Throttle.
From Water Supply.
Supplementary Water.
(Supplementary Water and Live Steam controlled automatically from One Float when Water Line falls in Heater to Supplementary Line.)
Exhaust from Engine to Heater.
Live Steam.
Normal Working Line
Supplementary Line
Continuous Supply of Water to Boilers at Highest Temperature.

FIG. 2. EXTERNAL CONNECTIONS OF HEATER

the heater. By the same means the water was cut off the moment the supply of steam ceased. In case, however, steam should not, for any reason, be admitted to the engine for a period exceeding, approximately, three minutes, the water level would fall within the heater, due to the continuous action of the boiler feed-pumps. As heaters are ordinarily arranged, a float would then, at a certain point, open the cold water supply valve, but in the present case this would not do unless steam were likewise admitted, as there would be no steam to heat the extra water.

Provision was therefore made that when the float should admit cold water during the idle periods of the engine, it should simultaneously admit live steam from the boilers. It may seem that it is poor economy to use live steam to do the work of exhaust steam, but there is another fact to be considered. The fires do not stop supplying heat to the boilers the moment the rolling-mill man shuts off his engine. The combustion of coal and the absorption of heat continue, so that the boilers shortly blow through the safety valves if some use is not made of the steam. The live steam used in the heater during times of inactivity of the engine is, therefore, as much waste steam saved as is the exhaust saved from the engine.

Determining Combined Resistances without Calculation

By F. H. Neely

Power-plant engineers, fortunately, do not often have to bother with the calculation of electric circuits, but occasionally the man in charge of a small plant is "the whole thing" and has to do everything, from seeing that the fireman is "on his

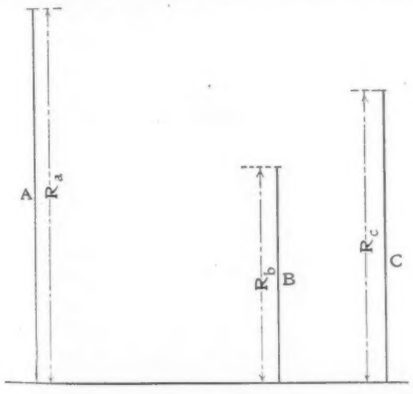


FIG. 1. LINES REPRESENTING RESISTANCES

job" to the laying out of wiring and testing of motors. To men of this class a method of finding out the total resistance of combined circuits without calculation should be useful. The formula for the resistance of several circuits in parallel is:

$$R = \frac{1}{\frac{1}{R_a} + \frac{1}{R_b} + \frac{1}{R_c} \cdots\cdots}$$

where the individual resistances of the different circuits are represented by the letter R and different subscripts and that of the combined group by R alone. This

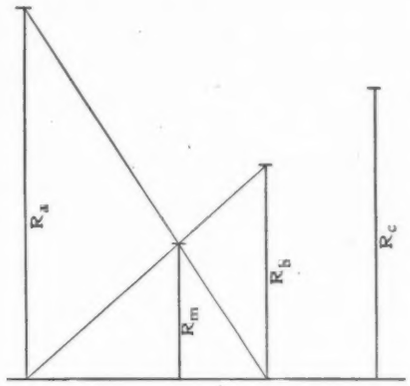


FIG. 2. COMBINING TWO OF THE RESISTANCES

is easy of solution, but tedious in application, and by using the graphic method described below, the reader may get rid of the abhorred algebra.

In using the graphic method it is nec-

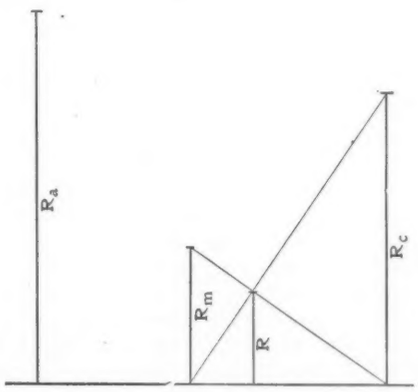


FIG. 3. COMBINING THE FIRST RESULTANT WITH THE THIRD RESISTANCE

essary first to combine the resistances of two of the circuits, then combine the result with the resistance of another circuit, and so on. Referring to Fig. 1, the resistances of three circuits are indicated by

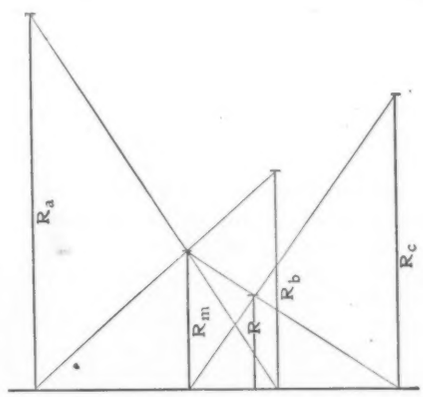


FIG. 4. COMBINATION OF FIGS. 2 AND 3

the three vertical lines A, B and C, which are drawn to a common scale of resistances, the lengths being proportional to the values R_a, R_b and R_c respectively. In the example, the resistance R_a was 32 ohms, and the length of the line A is 2 inches; the scale, therefore, is 16 ohms per inch; the resistance R_b was 18½ ohms and R_c was 25 ohms. To combine any two resistances, draw lines from the top of each vertical line to the base of the other; then draw a vertical line from the intersection of the two diagonals to the base, as in Fig. 2. Here the resistances R_a and R_b are selected for combination, and their resultant is the resistance indicated by the hight of the third vertical line, R_m.

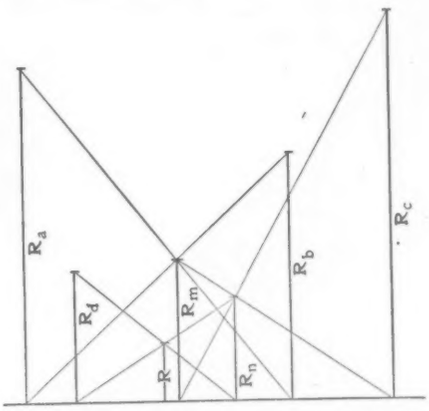


FIG. 5. COMBINING FOUR RESISTANCES ON ONE DIAGRAM

In Fig, 3 this resultant resistance R_m is combined with the third resistance R_c of Fig. 1, giving the result R as the combined resistance of the three original resistances. Applying the scale of 16 ohms per inch to this, its value is found to be 8 ohms. It is, of course, unnecessary to make a separate sketch for each operation; three or even four resistances may be combined in one diagram, as indicated by Figs. 4 and 5. The former is a composite of Figs. 2 and 3 and the latter a diagram showing four resistances, R_a, R_b, R_c and R_d combined, the result being R.

It is advisable to plot to a large scale if possible, making the longest vertical lines around 10 or 12 inches in length.

A Tall Chimney

The Eastman Kodak Company recently finished a brick chimney 366 feet high, 19 feet 6 inches inside diameter at the base and 9 feet inside diameter at the top, lined throughout with a 4-inch acid-proof lining, with a 2-inch air space between the walls. Custodis brick is the material, and the workmanship is so good that even upon close inspection the stack looks as though it had been turned in a monster lathe. It is said to be one foot higher than the chimney at Constable Hook, on New York bay, making it the highest this side of the Rocky mountains.

The Hydraulic Elevator—IX

Automatic Devices Used for Stopping Cars at Top and Bottom Landings, Their Care, and Their Value as Safety Appliances

BY WILLIAM BAXTER, JR.

The automatic devices employed to stop elevator cars at top and bottom landings are the most valuable safety appliances used, and they must be kept in perfect working order. For systems in which the cars are operated by the ordinary hand-rope method, the automatic stopping device is very simple. As shown in the fourth article of this series published in March POWER, it consists of two stop-balls fastened to the hand rope at the top and bottom in such manner that they will be caught by the sleeve through which the rope slides, a little before the car reaches the stopping point. These stop-balls are so adjusted that the sleeve strikes them at the proper distance from the floor level to cause the car to come to a state of rest three or four inches beyond the floor, if running at normal speed. As the careful operator usually pulls the hand rope to stop, the stop-balls are not often struck by the sleeve. When the car is stopped properly by the operator the reduction in speed is more gradual than would be the case if the stop-balls were relied upon.

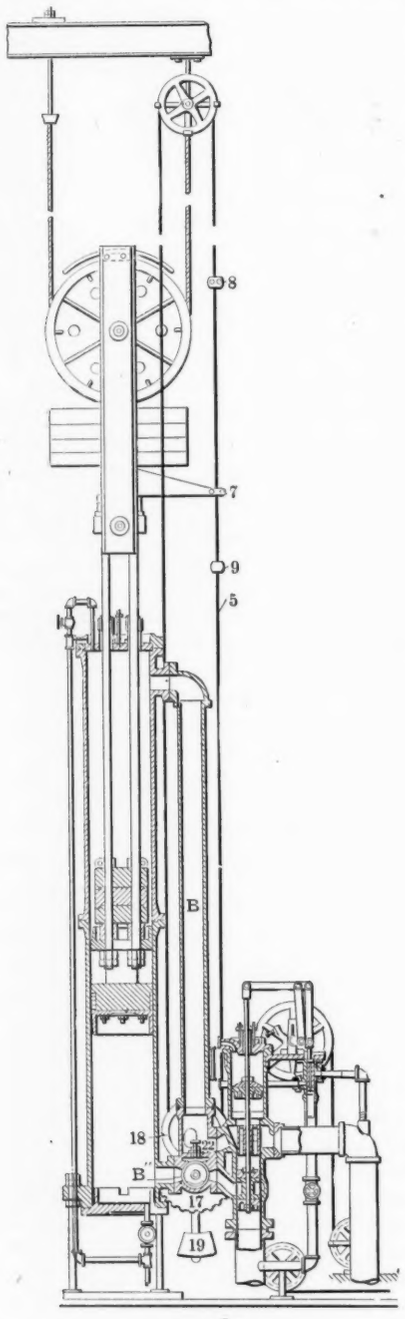


FIG. 81

Although it adds to the comfort of the passengers not to have the car stopped by means of the stop-balls, it makes it more imperative to examine the stop-balls frequently and carefully in order that there may be as little danger as possible of their getting loose and shifting out of place. If the car were frequently stopped by the stop-balls, any slight displacement of them would become apparent by the car running a little beyond the point where it should stop, indicating that the stop-ball had shifted. By taking advantage of this warning, the stop-ball can be returned to the proper position before serious damage results. If, however, the automatic stop is rarely used, the ball may become loose and shifted out of position a distance that would be dangerous. This is especially likely to occur with the bottom stop-ball, as gravity will cause it to slide down on the hand-rope after it becomes loose and it will not be in place to stop the car when needed. With the upper stop-ball there is not so much danger, because if it slides down it will only come into action too soon, and stop the car before it reaches the top floor. Yet it is possible for the upper stop-ball to become just loose enough to be pushed up on the rope when struck by the sleeve, and although it may not slide up far enough to permit the car to rise too high at the time, it will in all probability be high enough to fail to act when next called upon; therefore, the upper stop-ball requires nearly as much watching as the lower one.

STOP-VALVE FOR PILOT-VALVE CONTROL

In the case of pilot-valve elvators, the automatic stopping device is entirely separate from the operating lever in the car, and is actuated by the movement of the crosshead of the lifting piston. It is much more complicated than the stop-ball device, as it comprises a number of parts, and there is more chance for it to get out of order if neglected. A complete description of the automatic stop-valve and connections used with pilot-valve control was given in the April number, but the action of this valve and the way in which it should be adjusted will be more fully explained herewith, using for this purpose an elevation of so much of a vertical-cylinder hydraulic elevator as may be necessary to make the explanation clear. This elevation is shown in Fig. 81. It might be assumed that as this drawing represents only one design of automatic stop-valve for use

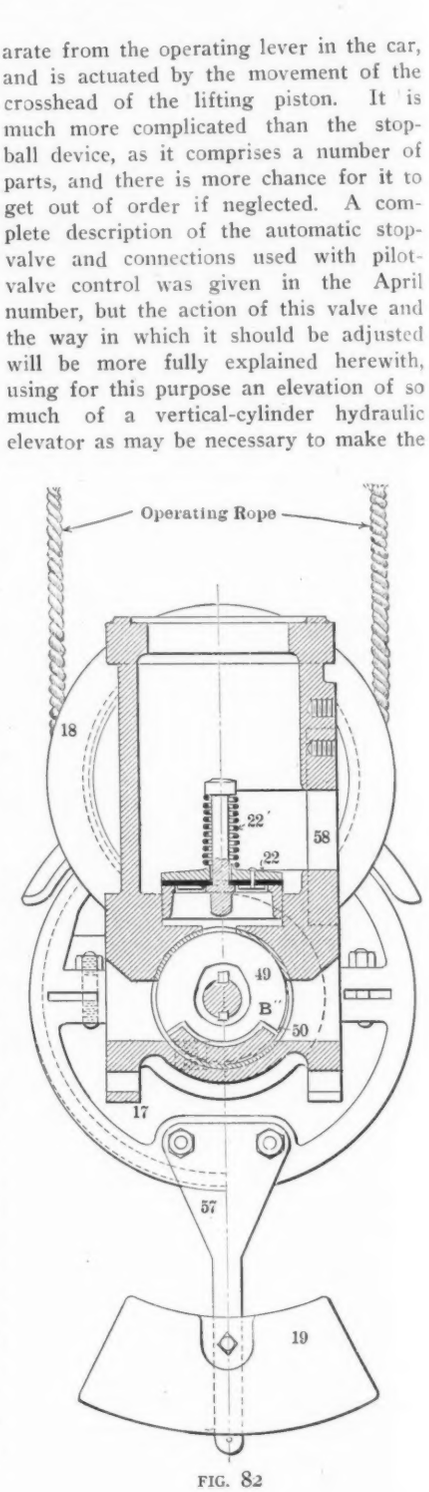


FIG. 82

with pilot-valve control, the explanation will be of service only in connection with this particular machine, but such is not the case; all hydraulic elevators provided with pilot-valve control are constructed upon the same principle, being different only in detail modifications, so that what is true of the general principles of operation for one is true of all, and all that is necessary is to take into account the changes in form of the various parts, which in most cases is trifling.

In Fig. 81 the automatic stop-valve is located at *B″*, and is actuated by the rope *5*, which runs upward by the side of the hydraulic cylinder to a point several feet above the highest position reached by the arm *7* attached to the crosshead of the machine. The rope *5* passes over a sheave at the upper end, as clearly shown in the drawing, and down around the sheave *18*, which is mounted in a bearing attached to the chamber of the automatic valve *B″*.

The arrangement and location of the sheave *18* can be better understood from Fig. 82. On the shaft of *18* there is a pinion that meshes into the gear *17*, which is mounted on the end of the shaft that carries the center *49* of the valve *B″*. The ratio between the diameters of the gear *17* and the pinion on the shaft of the sheave *18* is such that *17* makes a quarter of a turn between the instant when the arm *7* strikes either one of the stop-balls *8* and *9* and the time when the car comes to a state of rest. During this interval the flow of water through the valve *B″* is reduced so gradually as to bring the elevator to a stop without a noticeable jar if the velocity is not above the normal. The weight *19* provides the necessary momentum to return the stop-valve to the open position when the main valve is turned so as to move the car in the opposite direction.

In Fig. 81 it will be noticed that the arm *7* acts on stop-balls placed on the right-hand rope, therefore if the elevator is going upward, as *7* will be moving downward, the ball *9* will be struck, and thus the sheave *18* will be rotated clockwise, and the movement of *17* and the valve *B″* will be counter-clockwise; the curved plate *50*, Fig. 82, will swing around to the right side and cover the outlet from the lower end of the cylinder to the main-valve chamber, stopping the motion of the piston, and, consequently, the car. The curved piece *50* is held in the center carrier *49* loosely, so that while the pressure of the water trying to escape from the lower end of the cylinder will force it against the valve seat, to make a tight joint, if the main valve is depressed and pressure is brought on the outside of *50*, it will be forced away from the seat and water from the circulating pipe *B*, Fig. 81, will pass through the small opening slowly and produce a gradual start of the elevator.

As soon as the piston begins to move upward the arm *7* will also move, when gravity will draw the weight *19* downward to its lowest position. When the car is sufficiently near the lower floor for the automatic stop-valve to act, the arm *7* will strike the ball *8*, and by pulling up the right-hand side of the operating rope will rotate the sheave *18* counter-clockwise, swing the plate *50* around to the left and prevent the flow of water into the lower end of the cylinder.

Again, it will be seen that as long as the main valve is depressed the pressure will hold *50* against the seat, and prevent the escape of water from the lower end of the cylinder; but if the main valve is now raised, so as to connect the port from the valve *B″* with the discharge pipe, the pressure against the inner side of *50* will be removed, and the water in the lower end of the cylinder will force *50* away from its seat and escape, permitting the piston to move downward slowly; as the piston moves down, the arm *7* will also move down and free the stop-ball *8*, so that gravity again acting on *19* will swing it down to the central position and move *50* entirely out of the way of the flowing water.

If the plate *50* were not held loosely in the carrier *49*, the elevator could not be started after it had reached either end of the well, because the flow of water would be effectually stopped, and the opening of the main valve for either direction of movement would not have any effect. As the water used for operating elevators is generally clean, or at least free from bodies large and strong enough to wedge the plate *50* in the closed position, there is very little danger of an elevator becoming stalled through this cause. If, however, the car should refuse to start from either end, and no other reason could be found for its not moving, it could be inferred that the plate *50* was held firmly against the seat in some unexpected manner. Whether such were the case could be easily ascertained by placing the main valve so as to just open for the desired direction of movement, and then move the stop-ball away from the arm *7* to allow the weight *19* to drop to the central position. Upon doing this, if the elevator were set in motion, it would show that *50* had been caught, and then the valve chamber should be opened to ascertain and remedy the cause.

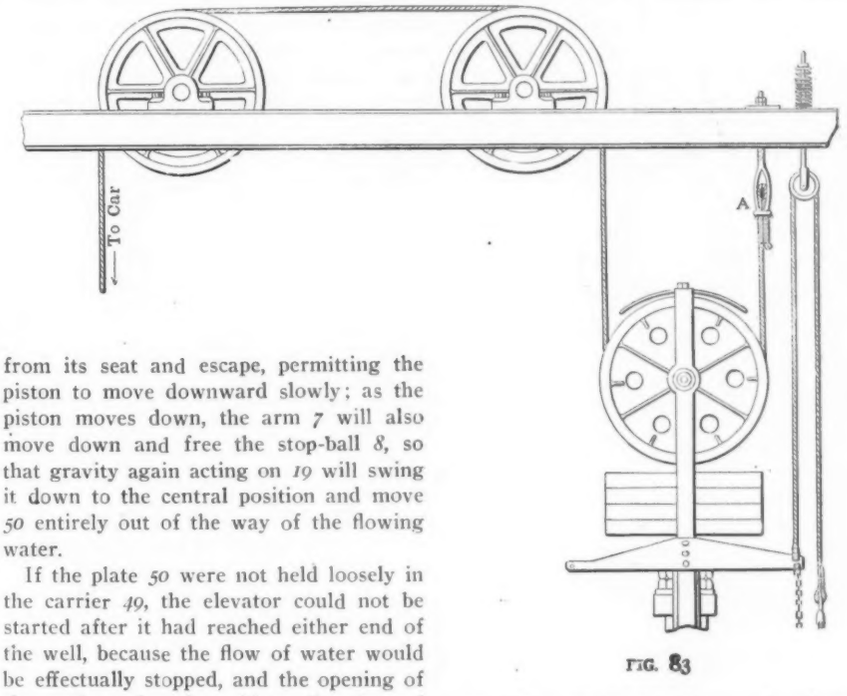


FIG. 83

To Remedy Defects Caused by Friction

While it is improbable that anything will cause the plate *50* to remain against its seat when the main valve is reversed, it is possible for the weight *19* to be incapable of overcoming the friction of all the moving parts of the automatic valve-gear, and when the main valve is moved into position to run the car up from the lower landing, or down from the top, the weight *19* may not return to the central position but remain at the side. If this should occur it would prevent the car from attaining a speed anywhere near normal; in fact, it would not run with much more than 10 per cent. of the normal velocity. To remedy a defect of this kind it is necessary to find out where the valve mechanism sticks, and put it in proper condition, which in most cases can be done by thoroughly cleaning, readjusting and oiling all the bearings and relieving any undue friction in the stuffing-boxes.

The refusal of the automatic stop-valve to return to the open position when the elevator is started from either end, due to the sticking of the moving parts, is not the most serious thing that can occur with it. Suppose the valve mechanism works so hard that when the arm *7* strikes one of the stop-balls it simply slides it along on the rope, what would be the result? Simply that the car would not stop but would pass the floor, and if at the bottom of the building it might strike the bumpers hard enough to injure passengers, unless the ropes were rather short, in which case the piston would be drawn up against the top cylinder-head before the car struck and damage the cylinder-head, piston or other parts. If the stop-ball were to slip when the car was running upward, the piston would strike the bottom cylinder-head, with more or less serious results. From the foregoing it

will be apparent that it is of the utmost importance to keep the automatic stop-valve mechanism in perfect condition all the time, the bearings and gears running freely and well oiled, and the stuffing-boxes tight enough to prevent leakage, but not too tight to prevent the valve-rod from revolving freely. The stop-balls must be firmly secured in position, and the fastening of the weight *19* must be perfect.

To secure correct running of the elevator the valve *22* must be in good order. If it leaks, the car will settle when standing at a landing, and if the spring *22'* becomes clogged and fails to compress freely, smooth stops will not be made when running upward or when the car is stopped at the top floor by the automatic

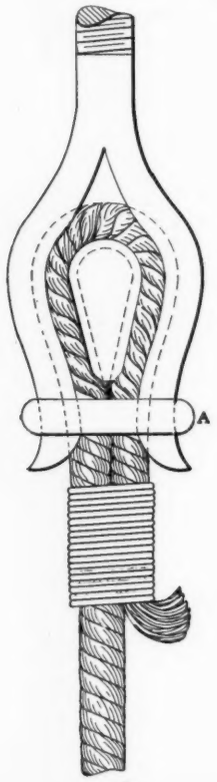


FIG. 84

valve, if the car is running at high speed. In such cases it generally happens that the operator closes the main valve too abruptly, and the automatic valve may close too soon; but if the valve *22* is working properly the excess of pressure developed in the lower end of the cylinder by the compressing action of the piston, due to its momentum, will force the valve up, allow the water to escape from the lower end of the cylinder into the circulating pipe, and permit the piston to move down some distance farther before coming to a stop.

The reason why the automatic stop is the most valuable of all elevator safety devices is that if the car for any reason runs down with abnormally high velocity, and all the usual safety appliances fail to act and stop it before it reaches a point near the lower landing, the automatic stop will begin to act and by gradually stopping the flow of water will arrest the motion of the car, so that if it does not stop before reaching the bumpers its velocity will have been reduced and a disagreable jolt will be the worst result. If elevator accidents were due to the actual breaking of the lifting ropes, the automatic stop would not be of such importance, but there are only a few cases on record where cars suspended from a number of ropes have dropped through the breaking of the latter. In nearly every case the elevator attains a dangerously high velocity through some disarrangement of the machinery, or, as it is generally expressed, the elevator "runs away." Since such is the fact, it is evident that if the automatic stops are kept in perfect working order every runaway can be prevented from doing serious damage, although if the car comes down at a sufficiently high velocity the escape of water through the relief valve *22* will continue long enough to permit it to strike the bumpers rather hard.

Effect of Stretching of the Ropes

Elevator lifting ropes stretch continually from the first day they are used until they are replaced, and the position of each automatic stop-ball has to be changed from time to time to compensate for the elongation. When the ropes are new they stretch rapidly, but after a few months' service they apparently stop stretching and remain at practically the same length until they begin to reach the point where they should be removed, then the stretching slowly increases. To guard against keeping in service a rope that is sufficiently worn to be in danger of giving out, it is necessary to make frequent inspections, but these inspections cannot be relied upon as infallible because even the most experienced men are not sure to detect every flaw. Examining grease-covered ropes in service is very different from inspecting new ones. The thoroughness of the operation can be greatly increased if the ropes are well cleaned with kerosene, but even when this is done it only enables the inspector to determine external conditions; the condition under the surface can only be conjectured. If the outside strands are badly worn or broken, it is time to put on a new rope. The fact that the ropes begin to stretch rapidly when reaching the end of their usefulness affords a means of determining their condition that should not be overlooked. Even if from external appearance they appear to be sound, they should be mistrusted if there is a noticeable increase in the rate of stretching.

If an elevator is provided with pilot-valve control the stretching of the ropes will cause the car to stop below the floors when arrested by the automatic stop-valves. Slight elongations of the ropes can be compensated for by shifting the stop-balls *8* and *9* downward. A considerable elongation cannot be compensated for in this way, because the effect of changing the position of the stop-balls is to cause the car to stop even with the floors, and to shift the piston out of position in the cylinder so that it will run closer to the lower end. As the clearance at each end of the cylinder is considerable, the position of the piston can be changed several inches without doing harm, but beyond this point the lower cylinder-head will be struck by the piston and possibly cause damage.

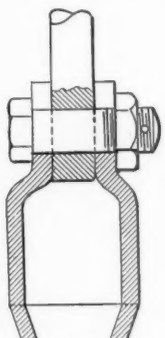


FIG. 85

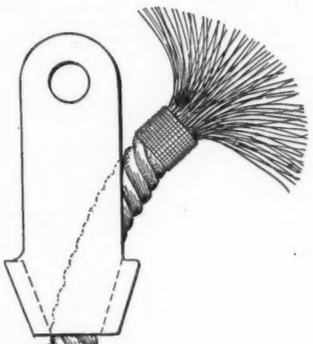


FIG. 86

FIG. 87

If an elevator is provided with hand-rope control the stretching of the ropes will not affect the stopping of the car, because this is controlled by the relative position of the stop-balls on the hand rope, and this will evidently remain unchanged regardless of the length of the lifting ropes. In such elevators the effect of stretch in the lifting ropes is to cause the piston to run nearer to the lower end of the cylinder and finally to strike it if the ropes are not shortened. The way in which the ropes are shortened can be easily understood from Fig. 83, which shows the overhead beams on which the main sheaves are supported, the traveling sheave and the method of securing the end of the rope. In elevators geared two to one, as in this illustration, the ropes are fastened to the overhead beams, but with higher gears they are secured farther down, generally to the beams that carry the intermediate sheaves, as was

shown in the first and second articles of this series, in POWER for December and January last. The end of the rope is firmly fastened in a long shackle-bolt, and when the rope is first installed its length is made such that the nut on the bolt is at the end. By drawing up the bolt, the

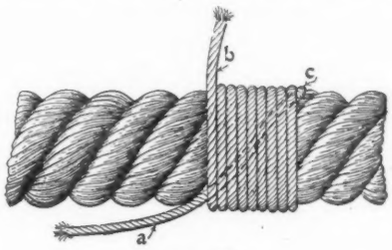


FIG. 88

rope can be shortened several inches. When the rope cannot be taken up any more by the bolt, it becomes necessary to cut a piece off the end of the rope.

To be able properly to keep track of the elongation of the ropes it is advisable to place a mark on some stationary surface in line with lowest position of some part of the traveling-sheave frame, then if the car is operated by a hand rope the stretching of the lifting ropes, as well as the amount of stretch, can be detected by noticing how far the traveling sheave runs below the datum mark. In the case of elevators controlled by pilot valves the distance the sheave runs below the mark will serve to show how near the piston comes to striking the lower cylinder-head and the ropes may be shortened before any damage is done.

How to Shorten the Ropes

The first thing to do is to ascertain how much to reduce the length. This can be determined by measuring how far the traveling sheave runs below the proper position and multiplying this by the gear of the machine. For example, if the sheave runs three inches below the datum mark and the gear is four to one, the ropes will have to be shortened one foot. The gear can always be ascertained, as it is equal to the number of times the ropes run up from the traveling sheaves. Having decided how much to take out of the ropes, the next step is to run the car down until it rests upon the bumpers, moving the automatic stop-ball out of the way for the purpose. Then a strong clamp is firmly fastened to the ropes several feet below the ends and this is drawn up by means of a tackle-block firmly fastened to the beams that sustain the shackle-bolts, until the latter have been raised enough to be free. The shackles are then removed, the ropes are shortened the proper amount and the shackles replaced, after which the ropes are drawn up by means of the tackle to raise the shackle-bolts high enough to run the nuts on their ends. There should be check-nuts on all the bolts, and in addition a safety-pin should be passed through a hole in the end of the bolt that there may be no danger of the bolt working off. This danger is greater than might be supposed, as the impression naturally would be that there is no movement of a rotative kind which would tend to loosen the nuts. On the contrary, there is a strong force all the time tending to twist each rope. As can be seen, when tension is placed upon the ropes it acts to untwist them, and if the shackle-bolts were held in frictionless bearings they would rotate, the number of turns increasing as the strain is increased. On removing the strain, the ropes would twist up again and rotate the shackle-bolts in the opposite direction. When the traveling sheave is moving down to lift the car, the strain on the ropes is greater than when it is moving upward to lower the car; therefore, the shackle-bolts are actually subjected to strong forces that tend to turn them in one direction when the elevator ascends, and in the opposite direction when it descends. On this account, if single nuts were used they would work loose in a

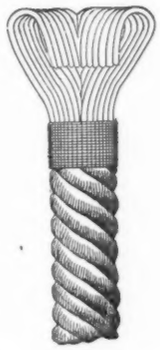


FIG. 89

FIG. 90

short time, and even check-nuts are liable to work free, hence the necessity of using safety-pins. The best plan of all, however, is to fasten the shackle ends by means of a piece of wire passing from one to the other, so as to prevent rotation as far as possible.

The course of procedure when shortening the ropes is as follows: If the shackle-bolt is of the design shown in Fig. 83, an enlarged view of which is given in Fig. 84, the ends are straightened so the clamp *A* may be removed; then the rope can be withdrawn and the wire binding taken off. The old bend in the rope is then straightened and another bend is made far enough down to shorten the rope the required amount. As the rope is stiff, strong clamps will be needed to bend it snugly around the center piece. While still clamped, the binding wire is wound on as tightly as possible, and if the distance between the end and the upper position of traveling sheave permits there is no objection to making the wire binding six inches, or even a foot, long. The ends of the wire should be turned outward and upward, as shown in Fig. 84, otherwise the rope may be drawn through the binding wire. If the end if unraveled and wound around the body of the rope, and then covered with the binding wire, the job will be much stronger, although it may not look so well.

Type of Shackle Used

The shackle shown in Fig. 84 is not as generally used as the type in which the end of the rope is fastened in a conical ring, with the ends of the wires bent over to form an enlargement to prevent pulling the rope through the ring. This kind of fastening, when properly made, is best of all, and will hold more securely than the rope itself. The shape of this shackle is shown in Figs. 85 and 86. In some cases the bolt is made part of the shackle and in others it is connected by means of a pin, as in the illustrations. To secure the end of the rope a binding band of wire is first put on at a distance from the point where the rope is to be cut off. That will leave ends long enough to bend over and fill the cone cup to the top, as illustrated at *a a*, Fig. 87, representing the point at which the rope is to be cut off, *b* being the binding band. This band is made of soft, iron wire (about No. 20), and to secure the ends of the wire firmly and neatly the winding should be done as shown in Fig. 88, the starting end *a* being run along in the space between the strands of the rope, the first turn of the band passing over the end, as shown at *c*, all the other turns being wound to the left. The band should be about three-quarters of an inch long, and the ends *a* and *b* are to be twisted together, and tucked under the band in one of the spaces between the strands.

It is necessary to put this band on before cutting the rope off, to prevent untwisting. It is also advisable to place a temporary band just below the cutting-off point, as indicated by the arrow at *c*, to facilitate the cutting. For the latter purpose a good hack-saw is best, although

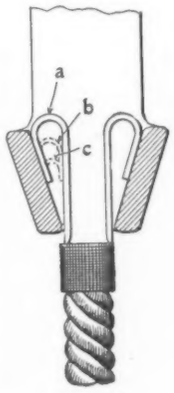


FIG. 91

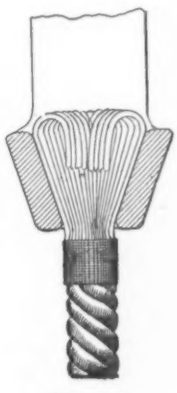


FIG. 92

a half-round file can be used, especially where there is no way of holding the rope firmly. After the rope has been cut off, it is passed through the shackle in the manner shown in Fig. 86, and the ends of the wire spread out. Next, the ends are bent over in the manner illustrated in Fig. 89,

but not as in Fig. 90. The latter way is easier and may on that account be resorted to, but it will not hold the rope safely under a heavy strain, as can be easily realized by looking at Figs. 91 and 92. In Fig. 91 it can be seen that the ends of the wire will be held against the sides of the cone by friction and the tension of the rope will draw the wires through, changing the position of the bend, as indicated by the dotted curves *b*, *c*, until the rope is pulled entirely out of the shackle. With the turned-in ends of Fig. 92 there is no possibility of pulling out. After the ends have been properly bent, the rope is pulled into the shackle by means of tackle, or screws, and the spaces between the bent ends of the wire are filled with molten babbitt metal, or zinc. Sometimes lead is used, but it is too soft to be reliable.

When new ropes are put on they are fastened at the ends in the manner stated. The easiest way is to remove and replace one rope at a time, first running the car down to the bottom of the building and shutting the supply-pipe valve. In putting on the ropes that connect with the independent counterbalance, they must be made of such length that the car will rest on the bumpers before the counterbalance strikes the overhead beams, and when the car runs up to the top of the building the counterbalance must strike its bumper before the car reaches the beams. The proportionate lengths of the ropes are shown in Figs. 93 and 94. In Fig. 93, if the ropes were so short that the counterbalance would strike the beams first, the ropes would undoubtedly be pulled apart. In Fig. 94, if the car ran into the overhead beams before the counterbalance struck the bumper, the ropes would be likewise pulled apart by the enormous force due to the momentum of the counterbalance. In the case of Fig. 93 the broken ropes would drop down the elevator well onto the top of the car, possibly with serious results to the passengers. In the case of Fig. 94 this also would generally be the case, as in most buildings the counterbalance runs in the elevator well at the side of the car.

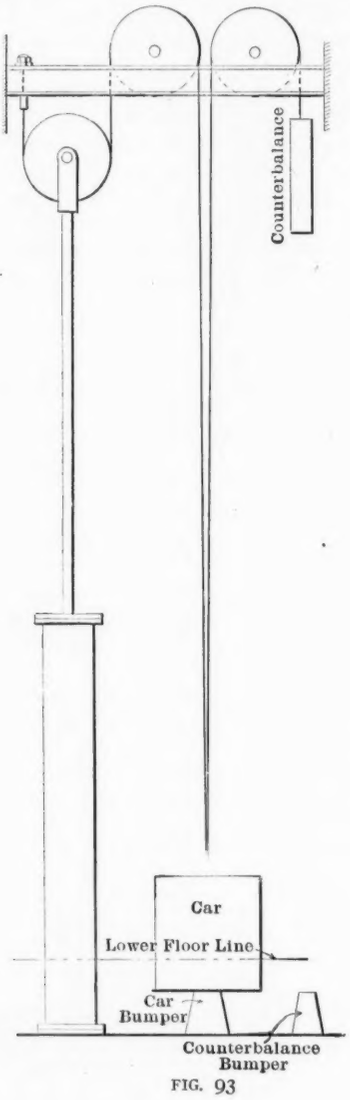


FIG. 93

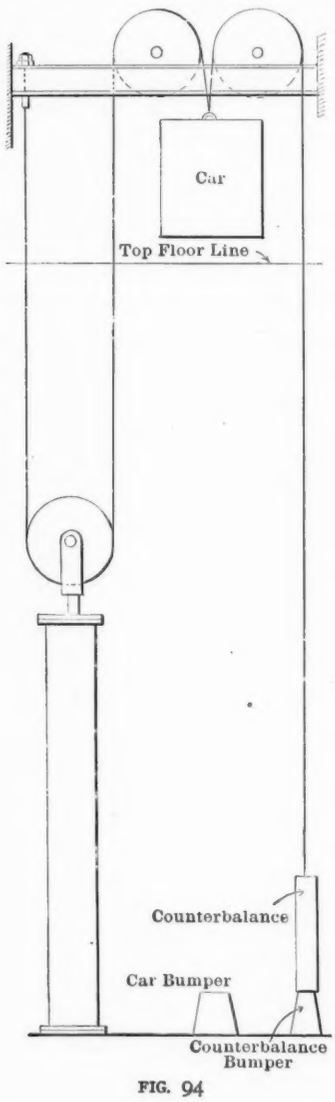


FIG. 94

There is a great demand in Great Britain for steam turbines and very low prices are being taken. Efficiencies are still going up, also.

Strength of Chains

By N. A. Carle

The factors entering into the strength of a chain are of such a nature that although the diameter of stock and kind of material are known, it is not easy to calculate the ultimate breaking stress. It has been found more satisfactory to test about 1 per cent. of the finished chain links to destruction and thus get a practical demonstration of the actual breaking stress. The carrying capacity of the chain is then rated at one-third of the average breaking stress, and the finished chain is given a proof test of one-half of the breaking stress.

These values have been tabulated over a considerable period, and an average value obtained for different sizes of chain which is now accepted as the carrying capacity for a properly constructed chain. A table of this kind is published in Kent's Handbook for "D. B. G. Special Crane" and "Crane" chains manufactured by the Pencoyd Iron Works.

The chart on page 607 is a graphical presentation of this table, showing the breaking stress and approximate weight for these two kinds of chains up to 1½ inches diameter. The factors of safety have been added for reading the safe working load directly from the chart.

Example

What will be the safe working load for a 1⅛-inch D. B. G. special crane chain with a factor of safety of 3?

Starting with 1⅛ inch "Size of Chain," read up to "D. B. G. Special Crane," then across to 3 "Factor of Safety," and down to 25,050 "Safe Working Load."

Example

What size chain should be used with a factor of safety of 4 for a safe working load of 25,000 pounds?

Starting with 25,000 pounds "Safe Working Load," read up to 4 "Factor of Safety," then over to "D. B. G. Special Crane," and down to 1 5/16 "Size of Chain." If ordinary "Crane" chain is selected the size would be 1⅜ inches.

It is to be noted that the D. B. G. special crane chain gives approximately 9 per cent. greater strength than ordinary crane chain. For chains from ¾ inch to 1½ inches diameter, a D. B. G. special crane chain is approximately equal to an ordinary crane chain of 1/16 inch larger diameter stock.

The Geological Survey has issued statistics showing that the coal production in the United States in 1906 aggregated 414,039,581 short tons, as against 392,919,341 in 1905. Pennsylvania leads with a total of 200,546,084 tons, West Virginia is second and Illinois third.

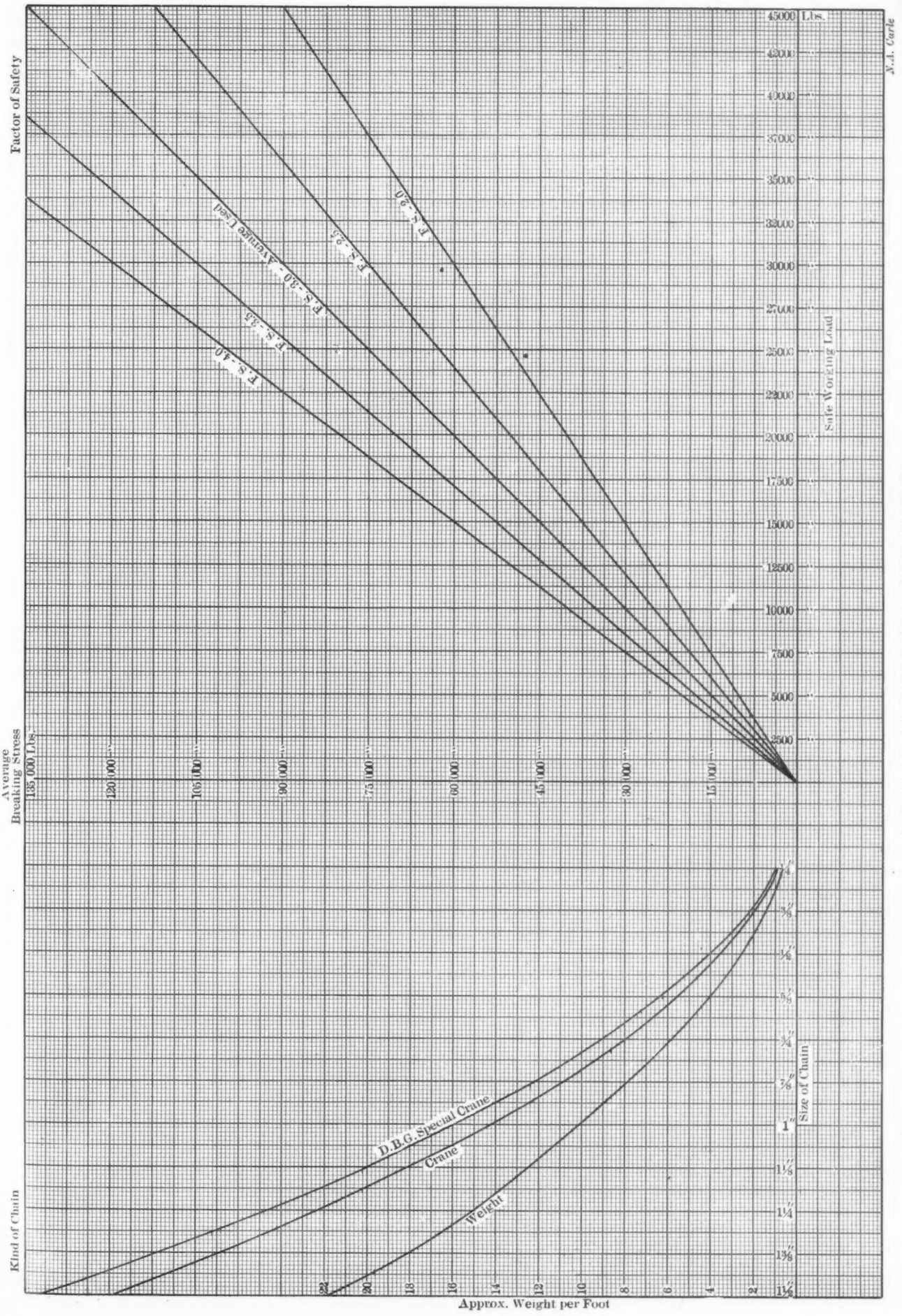


DIAGRAM FOR CALCULATING THE STRENGTH OF CHAINS

Test of Tube-connected Cylinders

By S. F. Jeter

If two cylinders connected by tubes as shown in Fig. 1 are subjected to internal pressure, there will be a force equal to the pressure per unit of area of the cross-section tending to pull them apart lengthwise. If there were no distortion of the tube sheets, each tube would be in simple tensile stress and bear its equal proportion of this load; but under the internal pressure the tube sheets, unless already spherical, tend to bulge, as shown in Fig. 2, in order to permit which there must be a buckling of the central tubes, an extension of the outer tubes, or a combination of the two; and if the central tubes are prevented from yielding, the whole load is thrown on the outer tubes. This concentration of the load upon these tubes causes the plate into which they are expanded to become distorted at this point, and bows the outer row of tubes outward, notwithstanding the tensile strain that they are under, while the deformation of the head causes the joints between the outer row of tubes and the head to be disturbed. This will be evident by a reference to Fig. 3, where a flexible joint *A* is introduced, for the purpose of illustration only, in the tube sheets. Here it is evident that the pressure indicated by the arrow at one end balances that indicated by the arrow at the other, and that the work of holding the two drums together against the pressure on the outward heads devolves upon the outer row of tubes. The writer has snapped off the ends of the outer tubes on boilers constructed on this principle when subjecting them to hydrostatic pressure as low as 210 pounds.

It is evident then that if the periphery and the ligaments between the tubes of the outer row can be so strengthened as to prevent the deflection of the plate at this point, and to transmit the strain to the outer tubes in the direct line of their length, so as to tend to pull them directly out of the sheet, the conditions of the joint between the head and tubes will be improved and the strength of the whole structure increased.

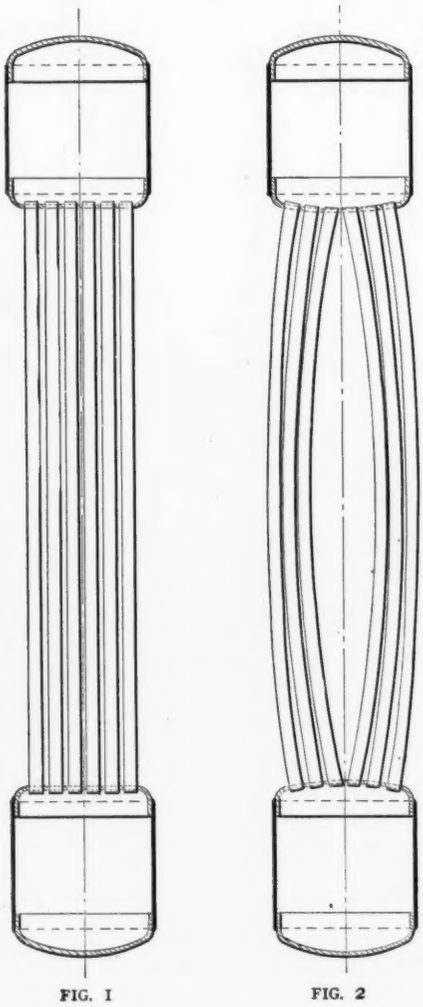


FIG. 1

FIG. 2

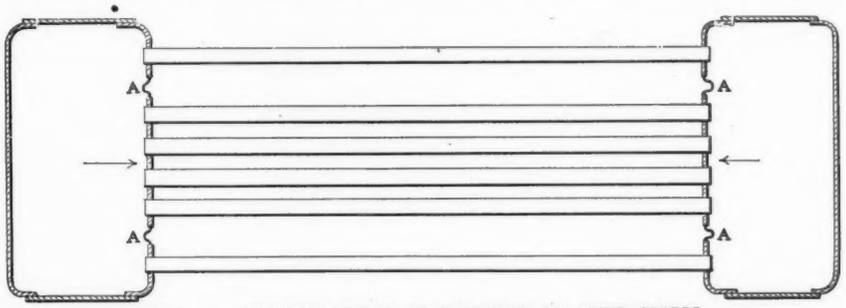


FIG. 3. SHOWING EFFECT OF PRESSURE ON TUBE STRESS

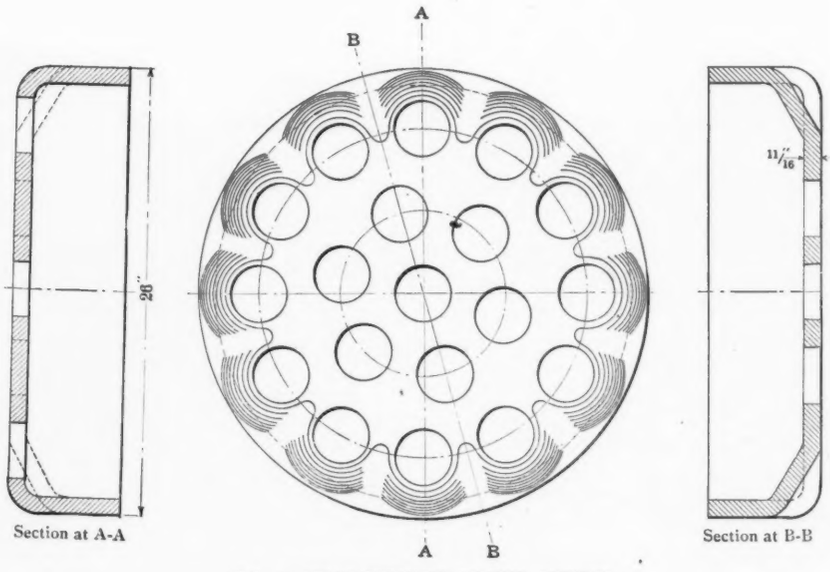


FIG. 4. HEAD DESIGNED BY THE AUTHOR

With this idea in mind I designed the head shown in Figs. 4 and 5, and present herewith the result of a series of comparative tests made between that form of head and the regular bumped head, shown in outline in Fig. 6 and at the right in Fig. 9; one of the heads in the latter is concave to pressure, and the other convex, so that all the tubes may be approximately of one length. In the first test both types of drum were 26 inches in diameter and tube plates 15/16 of an inch in thickness. Measurements were taken of the circumference of the nest of tubes at the center of their length, as shown in Fig. 7, the tubes being 18 feet long, or approximately 17 feet 9½ inches between the tube sheets.

The variation of this circumference was as follows:

Ribbed Tube Plate.	Pressures.	Dished Tube Plate.
5 feet 8¾ inches.	0 pounds.	5 feet 4½ inches.
5 feet 8 11/16 inches.	100 pounds.	5 feet 5 1/16 inches.
5 feet 8 13/16 inches.	200 pounds.	5 feet 5⅜ inches.
5 feet 9 1/16 inches.	300 pounds.	5 feet 6 1/16 inches.
5 feet 9 3/16 inches.	400 pounds.	5 feet 6⅝ inches.
5 feet 9 5/16 inches.	500 pounds.	5 feet 6⅞ inches.
5 feet 9 7/16 inches.	600 pounds.	5 feet 6 13/16 inches.

The next test was made on a ribbed plate 11/16 inch thick, and of the same diameter as before, against the same 15/16-inch dished plates.

Ribbed Plate.	Pressures.	Dished Tube Plate.
5 feet 10 13/16 inches.	0 pounds.	5 feet 4 3/16 inches.
5 feet 10 7/8 inches.	50 pounds.	5 feet 4½ inches.
5 feet 11 inches.	100 pounds.	5 feet 4¾ inches.
5 feet 11 1/16 inches.	150 pounds.	5 feet 5 1/16 inches.
5 feet 11 1/8 inches.	200 pounds.	5 feet 5 1/8 inches.
5 feet 11 3/16 inches.	250 pounds.	5 feet 5 3/16 inches.
5 feet 11 1/4 inches.	300 pounds.	5 feet 5 1/4 inches.

Direct deflections were taken with a micrometer at a point 4¼ inches radially from the circumference of the head, these tests being on ribbed plates of 11/16 inch thickness and dished plates of 15/16 inch

thickness. The bracket supporting the micrometer is shown at *A* in Fig. 7, and its use illustrated in Fig. 8.

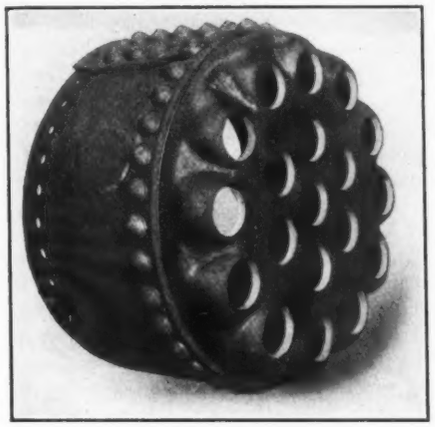


FIG. 5. HEAD DESIGNED BY THE AUTHOR

Dished Head Convexed to Pressure.	Dished Head Convexed to Pressure.	Ribbed Heads.	Pressure Tested at
0.281	0.276	0.2735	0
0.280	0.2725	0.272	50
0.2775	0.2695	0.270	100
0.2755	0.2665	0.269	150
0.2727	0.2632	0.2682	200
0.271	0.260	0.267	250
0.269	0.256	0.265	300
0.2655	0.2515	0.2625	400
0.262	0.243	0.260	500

pounds, it was decided to test the two sections together to a sufficient pressure to destroy them. No attempt was made in this last test to get any accurate data regarding the movement of the tubes or heads; a hydraulic line was used for making this test, upon which a pressure of 1500 pounds was carried. As the pressure rose, the apparent behavior of the sections was in all respects similar to what it had been in the former tests until a pressure of 750 or 800 pounds was reached. At this point the tubes in the section containing the dished head ceased to expand, and in fact began to recede. The pressure was increased until a maximum of 1000 pounds had been reached, and at this point the leakage was so severe that no further increase in pressure could be obtained. The tubes that were contained in the section with the ribbed heads continued to expand, and the center tubes at about 900 pounds pressure were forced out between those of the outer row, this being due to the change of form in the central portion of the heads.

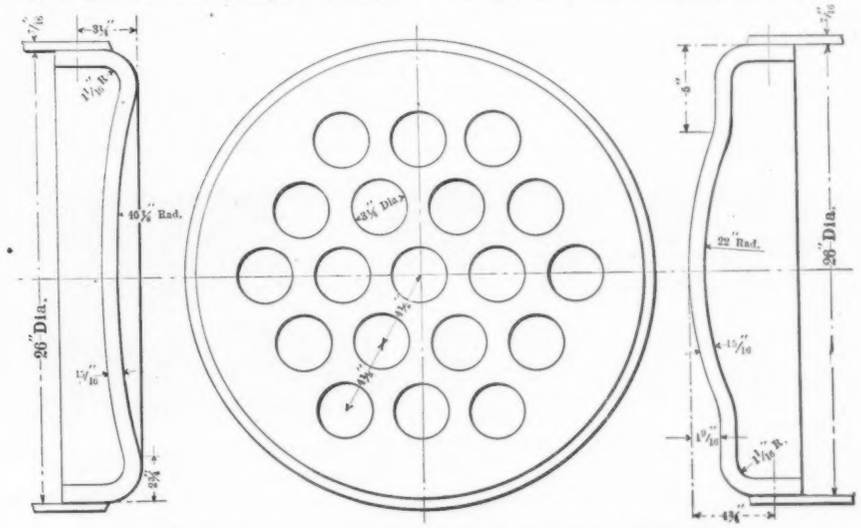


FIG. 6. SHAPE AND TUBE LAY-OUT OF THE REGULAR BUMPED HEAD

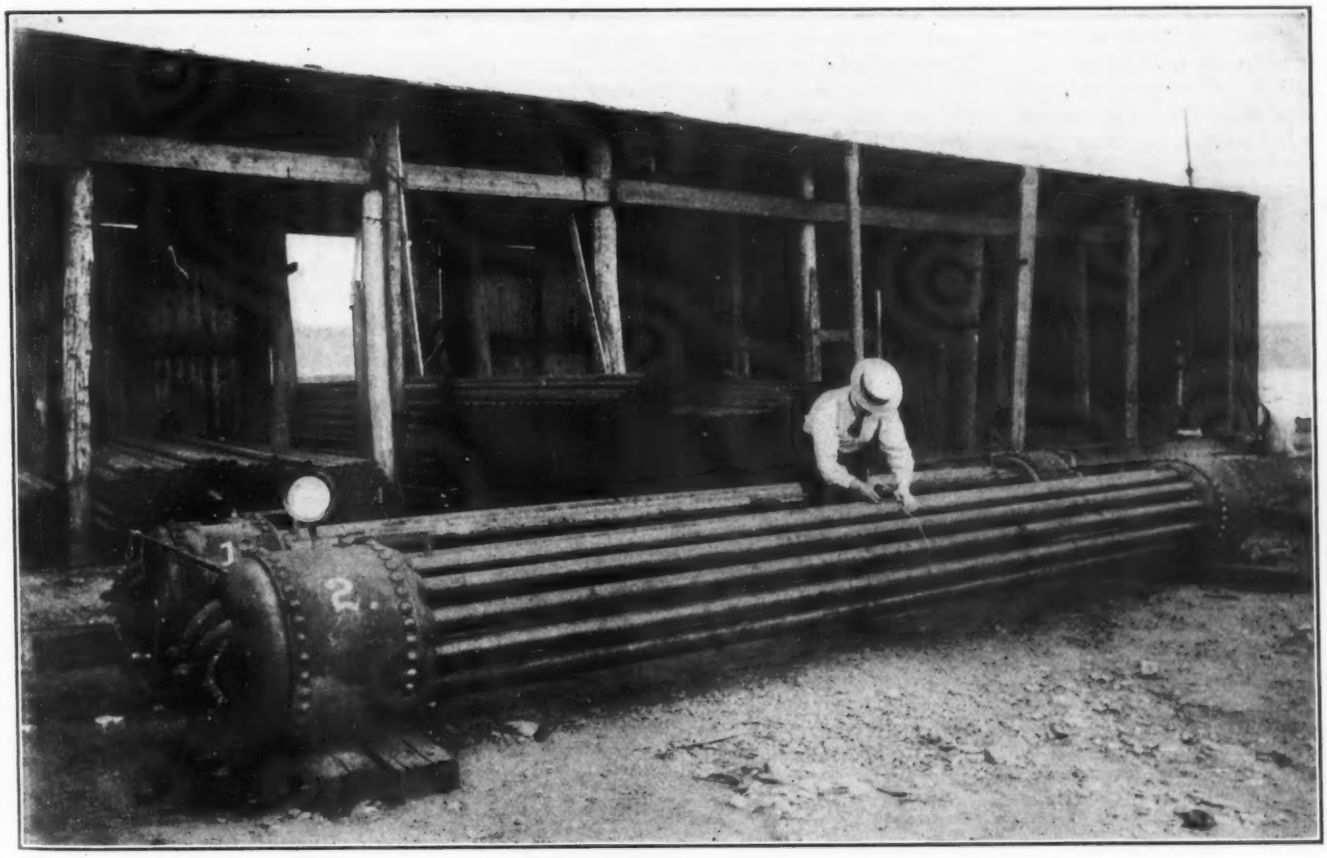


FIG. 7. THE TWO UNITS CONNECTED FOR TESTING. MICROMETER, AT "A." THE BULGING MEASURED AS SHOWN

The reason that the tubes ceased to expand on the section containing the dished heads was evident upon examination, it being found that the concave head had been so much deformed at the outer row of tubes as to cause them to slip in the tube plates and relieve the strain on the tubes, the tubes in the outer row having slipped out of the tube plate as much as

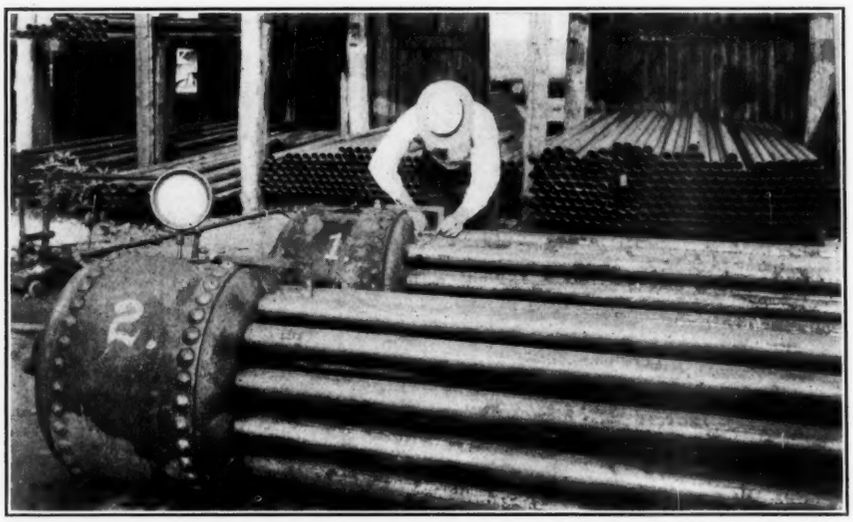


FIG. 8. MEASURING THE DEFLECTION WITH MICROMETER

7/16 or ½ of an inch in some instances, while the connection between the tubes and plate on the heads that were ribbed was hardly disturbed at all. This condition is apparent in Fig. 9.

The fly-wheel in the power house of the Interurban Railway and Lighting

FIG. 9. THE TWO HEADS AFTER TEST TO DISRUPTION

Company's system at McAlester, I. T., burst, July 16, wrecking the building and probably fatally injuring the engineer.

Boiler Feed-pumps

By F. F. Nickel

In selecting a feed-pump two factors enter into consideration, namely, capacity and speed. By capacity is meant the average quantity of water that the boiler which the feed-pump is to supply is capable of evaporating in a certain time, and it is clear that the feed-pump selected should be large enough to supply the maximum quantity of water that can be evaporated in the boiler. At the Centennial Exhibition a standard of 30 pounds per horse-power per hour was adopted, and while this is a safe figure to use when calculating the size of boiler required for a steam engine, it is too low to be considered as a basis for selecting feed-pumps, as the hereinafter considerations will show.

It is general practice among builders to furnish about 12 square feet of heating surface per horse-power, and it has been found that but little decrease of economy will take place if the boiler is forced to evaporate 4 pounds per hour per square foot of heating surface, instead of the 2½ pounds called for by the Centennial standard.

The A. S .M. E. committee on "Trial of Steam Boilers," in 1884 reported as its opinion that a boiler should be capable of developing its rated horse-power with easy firing, moderate draft and ordinary fuel, and further that it should be capable of delivering at least one-third more than its rated power to meet emergencies.

These considerations led to the adoption of 45 pounds per horse-power per hour as the quantity for which a boiler feed-pump should be calculated. This quantity must be delivered to the boiler at moderate speed, so that in case of low-water level in the boiler the pump can be speeded and the deficiency made up promptly. It is therefore good practice to reduce the speed of the boiler feed-pump to one-half of what the pump would be rated at for regular service.

The accompanying table gives average sizes of feed-pumps as furnished by the various builders, together with the proper speed, capacity and horse-power of the boilers they are intended to supply.

BOILER FEED-PUMPS.

Size.	Gallons per Revolution.	Strokes per Minute.	Piston Speed, Ft. per Min.	Gallons per Minute.	Pounds per Hour.	Horse-power of Boiler Suppl'd at 45-lb Rate.
3 x 2 x 3	0.155	80	20	6.2	3,100	70
3½ x 2½ x 4	0.265	76	25	10	5,000	110
4½ x 2½ x 4	0.395	76	25	15	7,500	170
5½ x 3½ x 5	0.805	70	29	28	14,000	310
6 x 4 x 6	1.265	66	33	42	21,000	470
7½ x 4½ x 6	1.6	66	33	53	25,150	560
7½ x 4½ x 8	2.15	60	40	65	32,500	720
7½ x 4½ x10	2.66	54	45	72	36,000	800
8 x 5 x10	3.25	54	45	88	44,000	1000
9 x 5½x10	3.6	54	45	97	48,500	1100
10 x 6 x10	4.75	54	45	128	64,000	1400
12 x 7 x10	6.45	54	45	174	87,000	1900
12 x 7 x12	7.75	48	48	186	93,000	2100
14 x 8½x10	9.55	54	45	258	129,000	2900
14 x 8½x12	11.5	48	48	276	138,000	3100
16 x10½x10	14.0	54	45	378	189,000	4200
16 x10½x12	16.7	48	48	401	200,500	4500
18½x12 x10	19.2	54	45	518	259,000	5800
18½x12 x12	23.0	48	48	552	276,000	6100
20 x14 x10	26.4	54	45	713	356,500	8000
20 x14 x12	31.5	48	48	756	378,000	8400

The Machinery Club of the City of New York will occupy the 20th and 21st floors (including roof garden) of the Fulton street terminal building of the Hudson & Manhattan Railroad Company, when completed. The temporary office of the club is at 26 Cortlandt street. While this is primarily a lunching club, it is expected that the new headquarters will become a general rendezvous for the machinery trade .

Instruments for Testing Direct-current Machinery

By E. S. Lincoln

It is seldom that the users of electrical machinery receive any data from the manufacturers beyond its rating, and this may be of great value and in some cases necessary. With this point in view, an outline of the important tests, and instructions for carrying them out, is the purpose of this article.

Before explaining the methods employed in the different tests, an outline of cautions will be given. In the first place, one never should assume that a wire is "dead," or that the voltage is very low. In other words, do not run any risk, never guess at it; you must *know* whether the voltage is high or low, or the current on or off. Every wire should be treated as though it were bare, and all joints should be thoroughly insulated.

A diagram of connections should first be made, and the actual connecting done in accordance with it. These connections should be as simple as possible and carefully arranged. They should be laid out in some systematic form and not just as they happen to fall. The wire should be proportioned to the current it is to carry and the apparatus thoroughly protected by fuses or circuit-breakers. In most cases the latter are preferable as they are easier to adjust and reset after operation. The setting of the circuit-breakers, or the rating of the fuses, must be carefully proportioned to the load they will carry. In the case of a 5-horse-power 220-volt motor, with an efficiency of 80 per cent., for example, the circuit-breaker should be set at 32 amperes, as this will allow for an increase in load of 50 per cent., the motor requiring about 21 amperes to deliver its rating. A 30-ampere fuse would be necessary if no circuit-breaker were available.

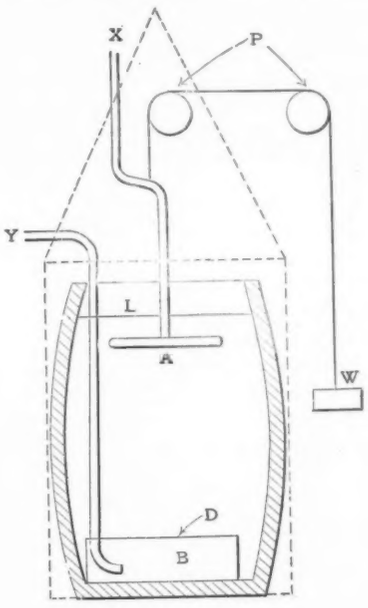
It is of great importance that all connections be carefully made, and they must also be scrupulously cleaned. This is especially important with regard to voltmeter leads, and good results will be obtained when these are made of flexible lamp cords with the ends soldered.

Whenever changing or examining any connections or apparatus, be sure that the current is turned off; never take any chances. Have the switches and instruments near the machine to be tested and preferably on a stout table, the legs of which should rest on felt blocks. The instruments should also rest on felt or some good substitute, to avoid jarring.

When any machine or apparatus is to be tested, there are several things of importance to be done. The first is to determine just what results are wanted, such as regulation, heating, characteristics, speed, etc. The second step is to draw the diagram of connections, which must include every piece of apparatus, every stretch of wire, and all instruments entering into the test. The diagram should indicate the ranges of all instruments, the sizes of wire, the current and voltage, the rating of the apparatus, and the setting of the protective devices. The next step is to connect the apparatus *exactly* as indicated in the diagram. When the wiring is completed it should be carefully inspected and the connections checked up by the diagram.

Measuring Instruments

As these are the most important factors which enter into testing, one should be very careful in selecting them. For this class of work portable instruments are best adapted and those of a type recognized as standard should always be selected.



A SIMPLE WATER RHEOSTAT

Every instrument should be very carefully handled and never subjected to jar or excessive vibration. The location of the instrument must be away from magnetic fields, and where a good light can be obtained so that the indications can easily be read. Instruments should be kept at least five feet away from field magnets and large currents in order to get accurate readings. In using a double-scale portable voltmeter, it is better to take all readings on the high scale first, to see whether the voltage is too high for the low scale. Be sure that all connections are clean and securely made, and never allow wires to come in contact with the metal case of the instrument.

All instruments should be cut out of circuit when not in use. In the case of an ammeter, this is usually done by short-circuiting the instrument without actually disconnecting its leads. This can be accomplished with a single-pole single-throw switch having capacity enough to carry the maximum current that is allowable through the ammeter. A plug switch is very convenient, as by drawing out the plug slowly, the current will rise gradually in the ammeter, and thus protect it in case the current goes higher than indicated on the scale of the instrument. The switch or plug socket should always remain closed except when a reading of the instrument is to be taken. Be sure that it is the ammeter that is short-circuited, not the voltmeter.

In using ammeters with external shunts, that is, with a shunt-block separate from the instrument one should be sure to use the leads furnished with the ammeter by the manufacturer. It is advisable to have a number of shunts for one ammeter, so that the one instrument may be used over many ranges. A voltmeter may also be used for higher ranges by means of a multiplier connected in series with the instrument. Its application will be illustrated under the subject of motor testing.

The glass of an instrument never should be wiped just before taking readings, as it tends to electrify the glass and cause errors in the readings.

Great care must be exercised in reading the indications of measuring instruments. If possible, two persons should read all instruments and compare results.

Resistances

It is important in almost all testing to have one or more forms of variable resistance that can withstand the full-load current of the machines tested. The value of the resistance will, of course, depend upon the power they are to absorb and the length of time that the current will pass. It is essential that rheostats of any form should receive great care, as negligence in this matter will cause considerable trouble. This is especially true with regard to water and water-cooled resistances.

For small currents at standard voltages a very convenient form of rheostat can be made by means of incandescent lamps of different candle-powers. A 110-volt 100-candle-power lamp will pass about 3 amperes, so that ten such lamps will give a good range for a 3-kilowatt machine and allow for an overload of about 25 per cent., according to the efficiency of the machine. The lamps may be mounted on the wall or a wooden frame and controlled by switches, or each lamp may be operated independently. To figure the number of lamps necessary to consume a given load, it is only necessary to know the voltage and candle-power of the lamps. The current can be found from these values by reference to a table. A 16-candle-power 110-volt lamp takes ½ ampere, a 220-volt lamp ¼ ampere, a 50-volt lamp 1 ampere; an 8-candle-power lamp takes one-half as much, and a 32-candle-power twice as much current as a 16-candle-power lamp of the same voltage. It should be remem-

bered that an excess over the rated voltage of an incandescent lamp will decrease its life greatly. This form of rheostat is expensive, but for small loads its expense may be justified by its convenience. In using lamps remember that the "hot" resistance is about one-half that of the "cold" resistance, due to the carbonized filament.

For taking larger amounts of energy, wire rheostats will be found convenient. The wire may consist of iron, copper or german silver, the latter having about twelve times the resistance of the copper wire. The amount of wire for any rheostat can be easily computed from a wire table. Galvanized-iron telegraph wire will be found very convenient and inexpensive for wire resistance. Its resistance is given the accompanying Table I, and other lengths can be figured from this. This wire is generally sold by the pound, so the table of weights will be found useful. As there are several grades of this wire, the figures in the table will vary more or less, but are accurate enough for practical purposes.

TABLE I. RESISTANCE AND WEIGHTS OF TELEGRAPH AND TELEPHONE WIRES

Averages of a large number of tests, within limits of specifications of the Western Union Telegraph Company.

American Steel and Wire Co.'s Gage.	Bundles per Mile.	Weight in Lb.		Resistance in Ohms.	
		Per 1000 Ft.	Per Mile.	Per 1000 Ft.	Per Mile.
6	3	102.29	540.08	1.63	8.62
8	2	73.66	388.91	2.27	11.97
9	2	61.82	326.43	2.70	14.26
10	2	51.78	273.40	3.22	17.02
11	2	40.49	213.80	4.12	21.77
12	2	31.15	164.46	5.36	28.30
14	2	18.30	96.65	9.12	48.16

In places where a considerable amount of testing is to be done, it is advisable to build a variable resistance outside of the building, and if it is made of wire it should be located in an exposed place, in order that the heat may be readily dissipated. This rheostat can be connected to the switchboard, and taps can be arranged to adjust the resistance by means of switches; or the contact points of an old rheostat can be connected to different points of the wire rheostat and the resistance thereby varied.

All resistances must be well insulated from the ground. The wire should always be exposed to the air or immersed in oil or running water, if the current is to remain on for any length of time. Only mineral oil should be used for cooling resistances and this in turn should be cooled by circulating cold water through pipes immersed in the oil. In any type of water- or oil-cooled rheostat, it is important that the level of the cooling liquid should be kept above the coils. The wires connecting the immersed coils and the terminals of the rheostat should be large enough to carry the maximum current.

In using a large wire rheostat for a continuous load, the wire should be shielded from any *intermittent* draft of air, as the sudden change in temperature of the wire will alter its resistance and cause the load to fluctuate. It is desirable to place a resistance frame in *steady* draft of cool air, and this will increase its carrying capacity.

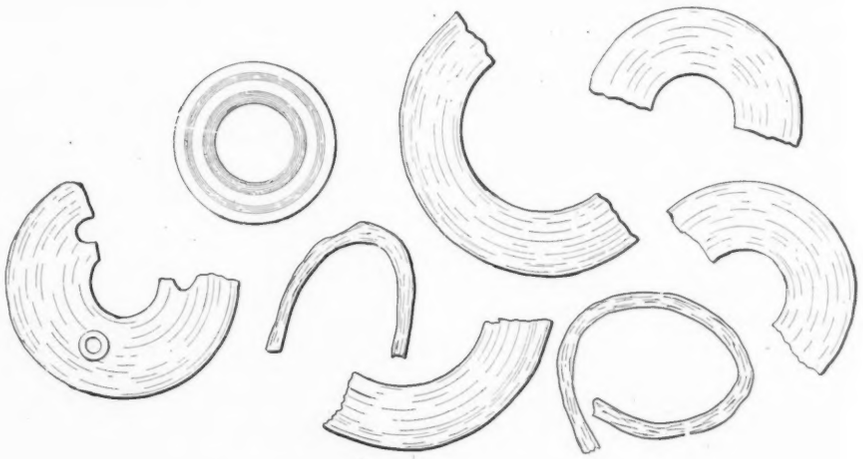
Another very convenient form of rheostat is the so-called water rheostat, and this type is capable handling a very large amount of enrgy. It is the cheapest and perhaps one of the most common forms in use. There are many ways in which a rheostat of this type may be constructed, the size being governed by the amount of power to be taken care of. A convenient type is illustrated herewith, and is capable of handling about 10 horse-power. It consists of a stout barrel filled with water to the level L (almost full). At the bottom of the barrel is fastened the stationary plate B, which is connected by a stout insulated wire Y to one terminal of the rheostat. The movable plate A is balanced by the weight W by means of a rope which passes over the pulleys P. The plate A is connected to the other rheostat terminal by the flexible conductor X. In order to prevent a dead short-circuit when the plate A reaches the bottom of the barrel, the sticks of wood D are fastened on top of the stationary plate B. The dotted lines inclosing the barrel represent an iron frame, which can be made of gas pipe, for making the rheostat portable by use of a crane, or the barrel can be mounted upon a truck, and thus made portable. The circuit can be broken by lifting the plate A entirely out of the water. Stove grates or circular pieces of sheet metal can be used for the plates A and B. Fresh water should be supplied occasionally to make up the loss due to evaporation. The capacity of the rheostat can be greatly increased by adding common salt to the water. It is advisable to change all the water in the barrel occasionally and give it a thorough cleaning out. Great care should be exercised when working around these rheostats while they are in operation, as any leak will cause a ground.

Before closing the subject of rheostats, attention should be called to carbon rheostats, which are useful where fine adjustments of small currents are desired. This type consists of a number of blocks of carbon resting on each other in an insulated frame. The resistance is varied by varying the pressure on the blocks. The end blocks form the terminals of the rheostat. If this form of resistance is allowed to heat, its resistances will decrease.

TABLE II. CURRENT CAPACITY OF IRON WIRE.

From *American Electrician.*

B & S Gage.	Safe Current in Wood Frame.	Safe Current in Iron Frame.	Safe Current for one Minute.	Number of Feet per Ohm.
8	17.4	20.3	43.6	250.0
9	14.6	17.1	36.6	173.0
10	12.3	14.3	30.8	137.0
11	10.3	12.3	25.8	108.0
12	8.7	10.0	21.7	86.4
13	7.3	8.5	18.3	68.5
14	6.1	7.0	15.3	54.3
15	5.1	6.0	12.9	43.1
16	4.3	5.0	10.8	34.1
17	3.6	4.2	9.1	27.1
18	3.0	3.5	7.6	24.3
19	2.52	2.9	6.3	16.5
20	2.17	2.5	5.4	13.5
21	1.82	2.1	4.5	10.7
22	1.53	1.77	3.8	8.49
23	1.28	1.49	3.2	6.73
24	1.08	1.20	2.3	5.34



PIECES OF A STOP-VALVE DISK THAT FAILED

The Danger of Insecure Valves

By W. H. Wakeman

In the accompanying illustration are shown accurately eight pieces that formerly composed the disk, and its supports, of a stop-valve located in a branch-pipe line that conveyed steam from the main line to one of the Corliss engines in a certain plant. The disk failed without apparent cause. Although some of the pieces

were too large to pass through the throttle valve, on account of the guide in it, others were carried into the steam chest and would have gone into the ports but for the peculiar shape of the casting. It was a narrow escape from serious trouble.

In another case the engineer of a large plant saw that one of his engines was not getting enough steam. He applied an indicator and found that although the initial pressure in the cylinder was normal, the steam line fell away rapidly as the piston advanced. Steam was shut off at the boilers and the stop-valve for that line examined. The disk was found to be detached from the stem, and it had fallen so as to partially cover the seat. As the valve was connected so that pressure acted on top of the disk when closed, this kept the disk from doing further mischief and held it where found, until it was removed to its original position.

If this valve had been connected so that pressure acted on the under side of the disk when closed, the accident would not have throttled the supply of steam, of course, but failure to do this would have prevented warning of its condition. In fact, it might not have been discovered until some other trouble made it necessary to shut off steam quickly, when if turning the wheel failed to stop the flow of steam a disaster might have resulted.

A globe valve was located in the feed-pipe of a battery of boilers, so that pressure from the boilers acted on the under side of the disk when it was closed. Water was forced through this pipe by a geared power pump. When the disk dropped from the stem of this valve and fell fairly on its seat, the pump caused a high pressure to accumulate and burst the pipe.

These accidents show the necessity of having the internal parts of valves well made and firmly secured in place.

The engineer in charge of the Savoy Hotel, London, England, commands a salary of £450 (about $2215) per annum. Upon the announcement a short while ago that the position was to be filled, 718 applications were received. The *Engineer-in-Charge* rightly says that this does not mean that there are 718 men worth £450 per annum, who are out of employment, nor does it mean that there are 718 men available who are worth that salary. Many of the applications are due to the effort of men already employed to better their positions. "The fact remains, however, that the possibility of earning a salary of £450 per annum in a very responsible and trying position has brought a veritable flood of applications. This emphasizes the fact that the remuneration of engineers-in-charge does not usually reach such figures and gives the opportunity of saying, what we have long felt, that the engineer-in-charge is too often underpaid."

Catechism of Electricity—XXVI

STATION ALTERNATING-CURRENT VOLTMETERS

520. *Do station alternating-current voltmeters differ greatly from portable alternating-current voltmeters?*

They are designed along the same lines

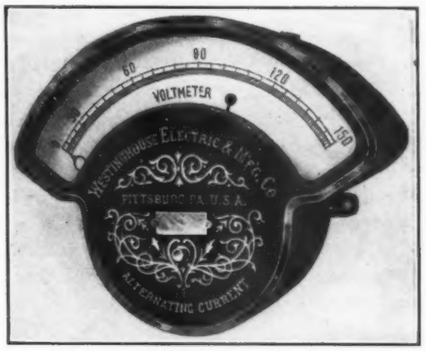


FIG. 126. STATION ALTERNATING-CURRENT VOLTMETER

as the portable alternating-current meters previously described. Their construction, however, differs from the portable instruments in order to adapt them for station work, but follows that of the station direct-current meters already shown.

Two typical forms of station alternating-current voltmeters are illustrated in Figs. 126 and 127. Both have iron cases, and graduated scales large enough to be read from a considerable distance. The meter in Fig. 126 has a scale of translucent material illuminated from the rear, the lamps at the back being mounted in a ventilated compartment entirely separate from that containing the mechanism. The meter in Fig. 127 is of the edgewise type, and being only 5¼ inches wide is preferable to the one in Fig. 126 when horizontal space on the switchboard is limited.

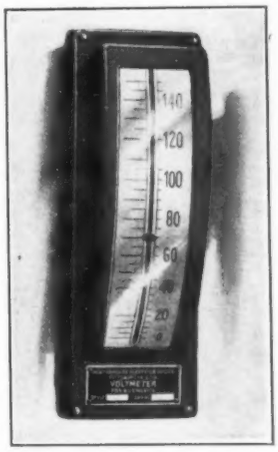


FIG. 127. EDGEWISE TYPE OF STATION ALTERNATING-CURRENT VOLTMETER

Ordinarily, the cases of alternating-current meters reading up to and including 150 volts contain the resistance coils also, but with voltmeters of higher capacity external resistances are used.

521. *Is an alternating-current voltmeter and multiplier connected directly across a high-potential circuit to measure its voltage?*

For potentials much over 750 volts it is not customary to connect an electromagnetic voltmeter and multiplier directly across the circuit. In such cases a step-down potential transformer is used, its high-pressure winding being connected across the high-potential circuit and its low-pressure winding to the instrument. A separate transformer is preferably used for this purpose. It is, of course, necessary where a transformer is used to multiply the reading on the voltmeter by the ratio of the transformer in order to ascertain the circuit voltage.

522. *Is there no instrument for measuring high alternating-current voltages directly?*

Yes; electrostatic voltmeters are used for that purpose.

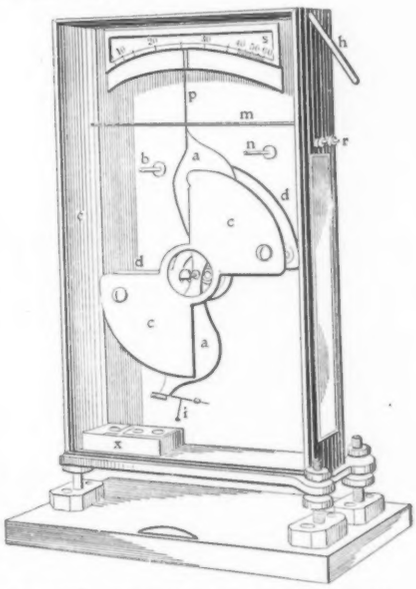


FIG. 128. ELECTROSTATIC VOLTMETER FOR MEASURING PRESSURES UP TO 20,000 VOLTS

523. *Illustrate and describe a common form of electrostatic voltmeter.*

Fig. 128 shows one of these instruments. In this form the meter is constructed to measure pressures up to 20,000 volts. The movable aluminum plate *a a* is pivoted on a horizontal axis between the two stationary brass plates *c c* and *d d*. One lead from the pressure main is connected to a terminal on the left-hand side of the inclosing case *e*, which may be of either wood or hard rubber; this terminal is permanently connected to the plates *c c* and *d d*. The other lead from the main is connected to the terminal *r*, which, in turn, is permanently connected to the spindle of the plate *a a*. This plate carries a pointer *p*, which indicates by its position over a vertical scale *s*, the potential difference between the mains.

With no pressure existing between the mains, the plate *a a* is entirely outside the

two plates *c c* and *d d*. When, however, there exists a difference of potential between the plates *c c* and *d d*, and the plate *a a*, there will be an attraction between them which will increase in proportion to the square of the potential difference, thus drawing the plate *a a* farther and farther in between the two plates *c c* and *d d*, and consequently carrying the pointer over the scale. The plate *a a* will

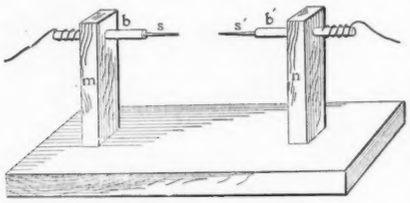


FIG. 129. DISCHARGE POINTS FOR USE IN CONNECTION WITH ELECTROSTATIC VOLTMETER

come to rest when the force due to the electrostatic attraction balances that of gravity.

To save time in reading, the oscillations of the pointer *p* may be checked by means of the brake *m*, which can be made to press on the pointer by turning the rubber handle *h*. The stops *b* and *n* prevent the plate *a a* from swinging too far and striking the pointer against the sides of the instrument. A set of weights contained in the box *x* may be used with each instrument to increase its range, one or more of the weights being hung on the movable plate at *i*, according to the potential being measured. The addition of each weight in succession doubles the previous range of the instrument.

When used on alternating-current circuits, owing to the great sparking distance of alternating currents, the electrostatic voltmeter should be subjected to a pressure not greater than 70 per cent. of the maximum for which it is rated, unless discharge points are connected in multiple with its terminals.

524. *What is meant by "discharge points"?*

Discharge points are usually formed by inserting steel needles *s* and *s'*, Fig. 129, in brass holders *b* and *b'*, which pass through insulated supports *m* and *n*. The brass holders should be capable of being moved back and forth in a horizontal line, so that the distance between the needles, which point toward each other, may be varied. The functions of the discharge points are to protect the voltmeter from higher voltages than it is adjusted to measure and to check the reading on the scale of the voltmeter.

525. *How is one to know the proper distance apart at which the needles should be set in measuring a certain voltage?*

Reference should be made to a curve showing distances between the needle-points and the voltages which will jump these distances. Such a curve is shown in Fig. 130. Having determined the proper distance corresponding to the voltage to be measured, the points of the needles are separated this amount.

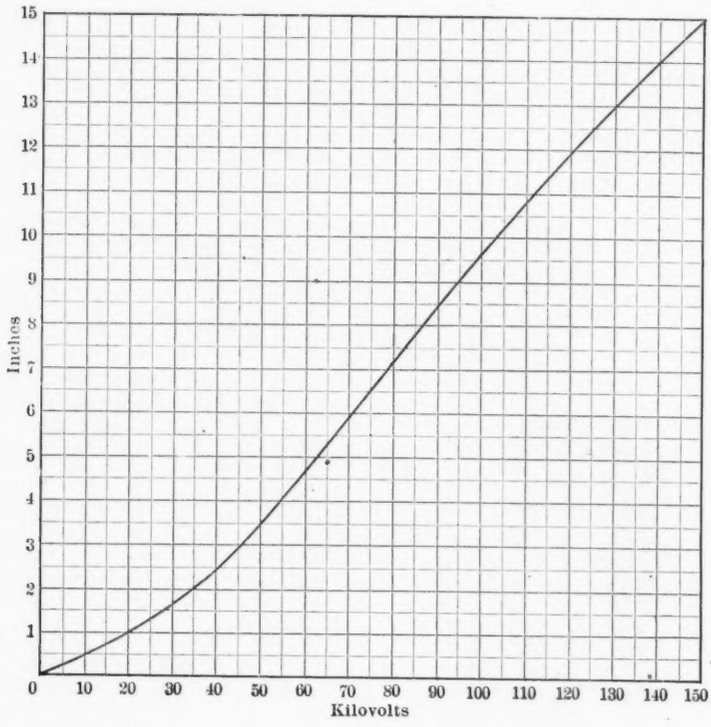


FIG. 130. CURVE OF SPARKING DISTANCES FOR HIGH PRESSURES

526. *Must any precautions be observed in using electrostatic voltmeters for measuring high potentials?*

Care must be taken to make the necessary connections to the wires before the voltage is on the circuit. Rubber gloves and other insulating devices used by electricians in working on live low-pressure circuits are absolutely worthless as protection from voltage such as would ordinarily be measured on electrostatic voltmeters. It is also important never to touch the case, or in fact any part of the instrument, when in use, except the rubber handle, as the leakage may be sufficient to cause a dangerous shock.

At each discharge, that is, when a spark

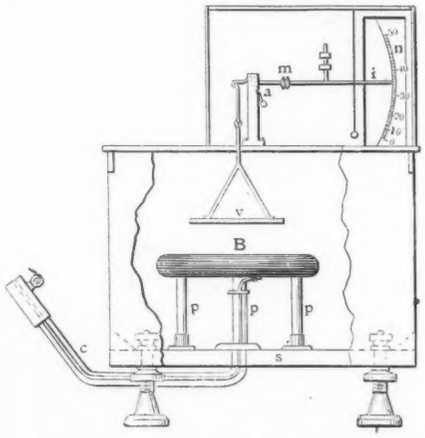


FIG 131. ELECTROSTATIC BALANCE FOR MEASURING PRESSURES UP TO 100,000 VOLTS

passes between the needle-points, the points of the needles become fused into knobs by the spark. This changes the conditions upon which the reference curve of sparking distances is based, and must be remedied by replacing the needles with new ones before the next measurement. Care must be taken, however, to open both switches connecting the measuring apparatus to the high-potential circuit before making the change.

Two single-pole switches must be used, one in each side of the circuit joining the measuring apparatus to the high-potential wires. The switches must be placed sufficiently far apart that there will be no possibility of the applied voltage jumping across them, and they should be mounted vertically so that gravity will tend to open the switch blades rather than close them. Under no circumstances should a double-pole switch be used in place of the two single-pole switches just mentioned.

527. *Can voltages higher than 20,000 volts be measured directly?*

Yes, voltages up to 100,000 volts can be measured directly on the electrostatic balance shown in Fig. 131.

528. *Describe the electrostatic balance.*

Referring to Fig. 131, the fixed portion of the meter is shown at *B*, the inclosing case being broken away to show the interior; *B* is a brass plate, supported above a slate base *s* by three glass pillars *p p p*. The movable portion consists of an aluminum disk *v*, suspended by long links from the short end of the balance arm *i*. The balance arm indicates, by its position over a scale *n*, the potential difference between the two plates *v* and *B*.

As in the electrostatic voltmeter, Fig. 128, a brake is provided to check the oscillations of the pointer. In this instrument it consists of a weighted cord suspended from the top of the case and pressing lightly against the balance arm *i*, as shown. A heavily insulated wire passes through the glass tube *c*, and makes contact with the brass plate *B*. The end of this wire, marked *b*, forms one terminal of the instrument. The aluminum plate *v* is grounded on the inclosing brass case by means of its support, which, as seen in the figure, rests on the top of the lower case. Any portion of the brass case may, therefore, be used as the other terminal of the instrument.

A set of weights for use on the arm at *m* greatly widens the range of the instrument. When adjusting the weights or moving the instrument, the movable portion is held in a stationary position by pressing the lever *a* in line with the support. The electrostatic balance, by the use of the weights just mentioned, is designed to measure pressures from 5000 to 100,000 volts.

529. *What precautions should be observed in using an electrostatic balance?*

The same precautions specified in answer to Question 526.

530. *Have static voltmeters or balances any special advantages for measuring voltages of ordinary value?*

They are not influenced by external magnetic fields nor by the frequency of the current. They are direct-reading on either direct- or alternating-current circuits, require an extremely small consumption of energy to operate them, cost little in comparison with other forms of voltmeters, and require no reducing transformers. They are particularly valuable in high-tension plants as a guide for the attendants regarding whether the circuits are alive.

531. *Have electrostatic meters any special disadvantages?*

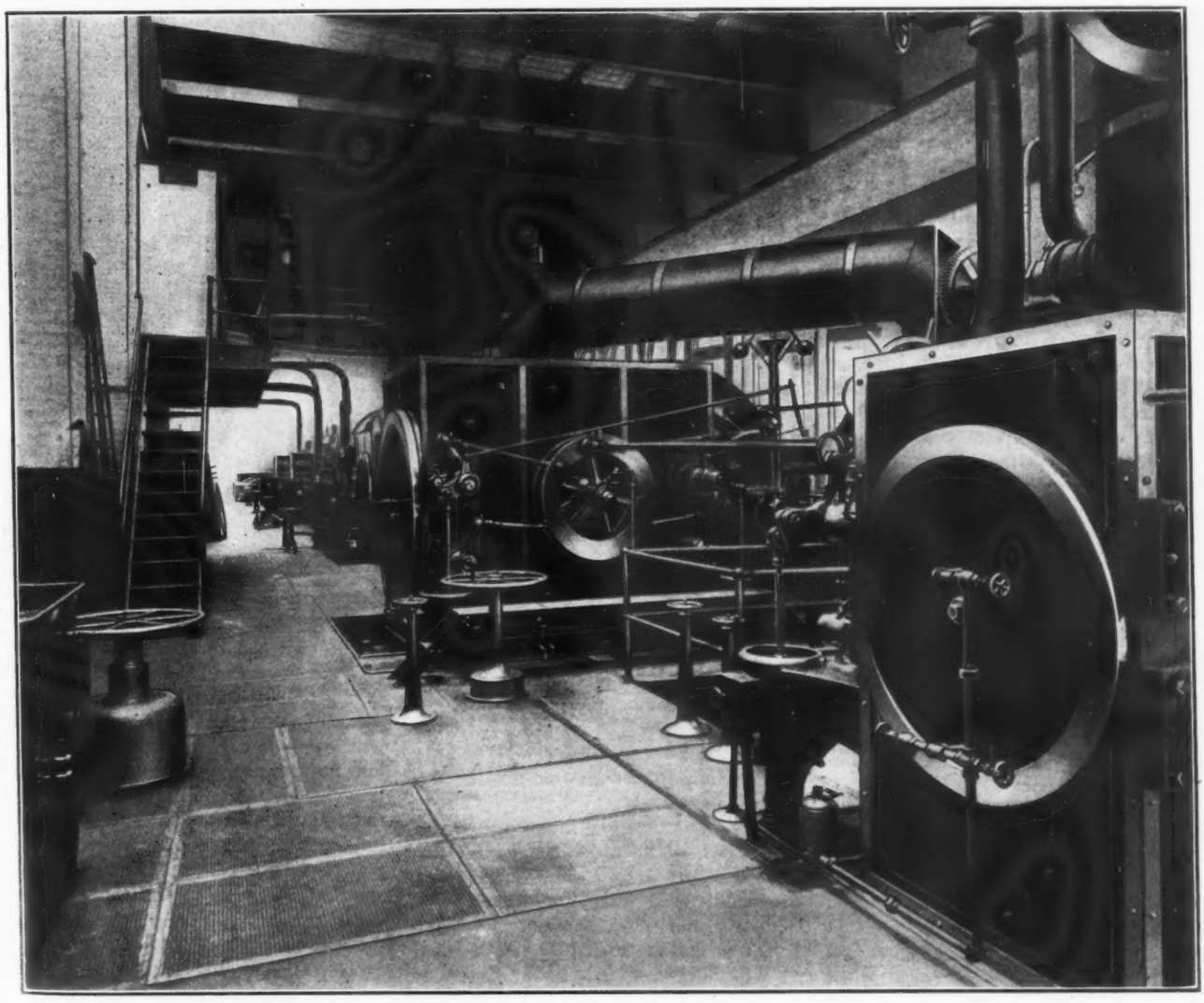
They do not give as accurate results as other types of voltmeters, the error being usually between 1 and 2 per cent.

Record of Allis-Chalmers Engines at Chicago

After nine and a half years of service, running 20 hours a day at 80 revolutions per minute, a recent annual inspection of the engines installed at the power house of the South Side Elevated Railway Company, of Chicago, indicated that the amount of wear in the 54-inch low-pressure cylinders of the 26 and 54 by 48-inch Allis-Chalmers cross-compound machines constituting this equipment measured the thickness of one sheet of paper sidewise and two papers top and bottom, using paper sheets of from 0.010 to 0.011 of an inch thick.

The measurements were taken on the No. 2 engine, which is one of four units earliest installed. The cylinder was opened under the direction of the chief engineer. The same steel gage was used which was made when the engines were erected. Furthermore, the original bull-rings and packing rings are still in use in this cylinder.

In this connection it is interesting to note that current has never been off the bus-bars at this station since it was first put into operation. The station now contains the four horizontal units mentioned, two 34 and 70 by 54-inch engines of the same type, and two 38 and 80 by 60-inch Allis-Chalmers vertical cross-compound engines.



ALLIS-CHALMERS HORIZONTAL HEAVY-DUTY ENGINES AT SOUTH SIDE ELEVATED RAILWAY PLANT, CHICAGO

The CO_2 Motor: The Latest Mechanical Fake

Another Demonstration of Getting Something for Nothing
Only Twenty-five Dollars a Share for Stock in a Clumsy Trick

There is only one man in the world who knows what electricity is.

He is John E. Carroll, of Philadelphia.

It is oxygen.

Mr. Carroll says so, and if you are from Missouri break it gently, for Mr. Carroll is positive and resentful of any hesitancy to accept his revelations at their face value.

A curly-headed blue-eyed Irishman with a five-carat diamond in an outing shirt, and another but slightly smaller on his finger; illiterate and glad of it, but on speaking terms with a few big words which he works overtime, Mr. John E. Carroll presiding over a demonstration of the CO_2 motor is the best thing we have ever seen off of the stage.

The CO_2 motor has Philadelphia by the ears. We have wondered before why Philadelphia was such a fruitful ground for the mechanical gold brick; and still the wonder grows. Did Keely see or make its possibilities? Engineers of at least ordinary sense are discussing its possibilities; rumors are afloat that the automobile privilege has been sold for two million dollars and the advertising pages of the Sunday papers teem with indorsements from "chief engineers" who ought to know better, if they are responsible for the utterances imputed to them.

We had the pleasure of attending a "demonstration" recently. It was a special demonstration for the benefit of "parties" in the automobile line. Upward of a dozen men gathered in a little room, the walls of which were covered with zigzags of tinfoil and the doors of which were guarded with the gratings of a burglar-alarm system, while in a corner stood a large safe into which the vital parts of the machine are put at night so that the minions of the Standard Oil Company and the United Gas Improvement Company (which see in the success of this invention the downfall of all their inflated greatness) may not wrest the secret by force of arms. The visitor is told mysteriously that several such minions are in durance vile already, having been intercepted in such attempts.

The guests having been seated and provided with blue-covered "programs of demonstration," the Sage of the Crystalized Carbon introduced the exercises with the announcement that carbonic acid is one of the wonders of nature—that and muriatic acid—that it is the first thing you take into your stomach when you are born and that you will die just exactly as quick if carbonic-acid gas is taken away from you as you will if you take oxygen away—just to the instant. He has collected "dato" to that effect. "Carbonic acid gas is a thing that there hain't any equilibrium to. You can't get any equilibrium in it if you work it with temperatures."

When the capacity of the audience to absorb this kind of charlatanism without too violent a protest has been demonstrated, the Sage, with the assistance of a colored attendant, connects a steel tank, apparently such as is used to charge soda fountains and said to be full of compressed carbonic acid, to the lower of the two tanks shown on the back of the engine in the accompanying engraving, and turns the gas into the cylinder until the gage attached thereto indicates 450 pounds. He then starts the engine and runs it exhausting into the upper tank, until the pressure in the lower tank is exhausted and the engine stops. One of the audience is then invited to open the gage upon the upper tank, which has been shut off meanwhile, and Presto! the pressure of 450 pounds appears in the tank into which the engine has been exhausting.

Mr. Carroll's explanation of how an engine can run on a gradually decreasing initial pressure against a gradually increasing back pressure and continue to run when the back pressure exceeds the initial by 450 pounds, was so far beyond our finite comprehension that we are unable to record it.

"How much was that charge that you put in there worth?" we asked.

"About four cents."

"How long will it run the engine?"

"Forever if there is no leakage; about 30 days with the stuffing-boxes as they are now."

"Without the application of heat or energy from any other source?"

"Certainly, all you have to do is put in the charge just as I did and the engine will run as long as the charge lasts."

"And it only costs four cents?"

"That's all."

"Then it wouldn't cost much to do that over again?"

"Sure, if you are not satisfied."

"All right. Do it again and leave that top gage open so we can see the pressure build up and be sure the engine is running against a back pressure."

"Oh, you can't do that."

"Why not?"

"All the physical 'dato' we have goes to show that carbonic-acid gas cools when expanding. If I left that gage on there it would go into pieces, get as brittle as glass. There isn't a metal in the world that will stand the intense cold that is produced by the expansion of that gas."

His attention was called to the fact that "the tank did not show any evidences of cold, in fact remained at about the room temperature."

Oh well, the gage was attached to an interior tank insulated by a vacuum and no amount of insulation, no siphon nor other known device would prevent the gage from going into smithereens if it were attached while the engine were working, although it had no difficulty in indicating the pressure from the same source when the demonstrator got ready. What dispelled this awful frigidity was left to the imagination of the demonstratees, and a portion of it seemed to settle upon the crowd.

But the main demonstration was to charge the lower tank again and run the engine until the pressure became equal in the two tanks, when the engine continued to run with no apparent change of conditions.

The little truck upon which the engine sat was wheeled over some newspapers to show that there was no connection through the floor, and a little generator (?), the name plate of which bore the following legend, attached by a pinion gear:

"2 kw. 1350 r.p.m., amp. 16"
"125 volts Sprague-Lundell"
"13152 F"

The engine was then started up and a switch thrown, lighting 41 eight-candle-power lamps upon a switchboard suspended from the ceiling.

The engine continued to run during the rest of our stay, an hour or so, and the lamps to burn with no apparent source of energy.

The switchboard was an asbestos-covered wooden affair suspended from the ceiling by two short hinges upon bolts in the ceiling. It had a two-bladed switch with one pole unconnected and a rheostat, but no ammeter nor voltmeter. While the demonstrator was explaining something at the switchboard one of the visitors opened the box with which the commutator of the generator (?) was shielded and started to lift the brushes.

But the wary demonstrator was right there.

"Here don't touch that!"

"Why not?"

"Why! it will knock you stiff."

"Oh, I guess not, I have lifted them before."

"Not on this machine you haven't."

"Well you lift them then."

"I *will* not."

"Why?"

"What do you want them lifted for?"

We suggested that if the juice which was running that bank of lamps was coming out of that commutator, of which we were very much in doubt, the lifting of the brushes would show it.

"Well they won't be lifted. You think that's a motor don't you?" and the Sage proceeded to lose sight of the issue by reproaching the inquirer who had come there as his guest with interfering with the demonstration, "and imputing his honesty."

We were duly apologetic and offered, if our request embarrassed him, to withdraw it.

The Sage became excited and assertive.

"Will you stand in front of that engine if I lift those brushes?" he demanded.

"Yes."

"Do you know that the instant I lifted those brushes that engine would fly into a thousand million pieces?"

"No, nor I don't believe it."

"And you will stand there right in line with it if I lift the brushes?"

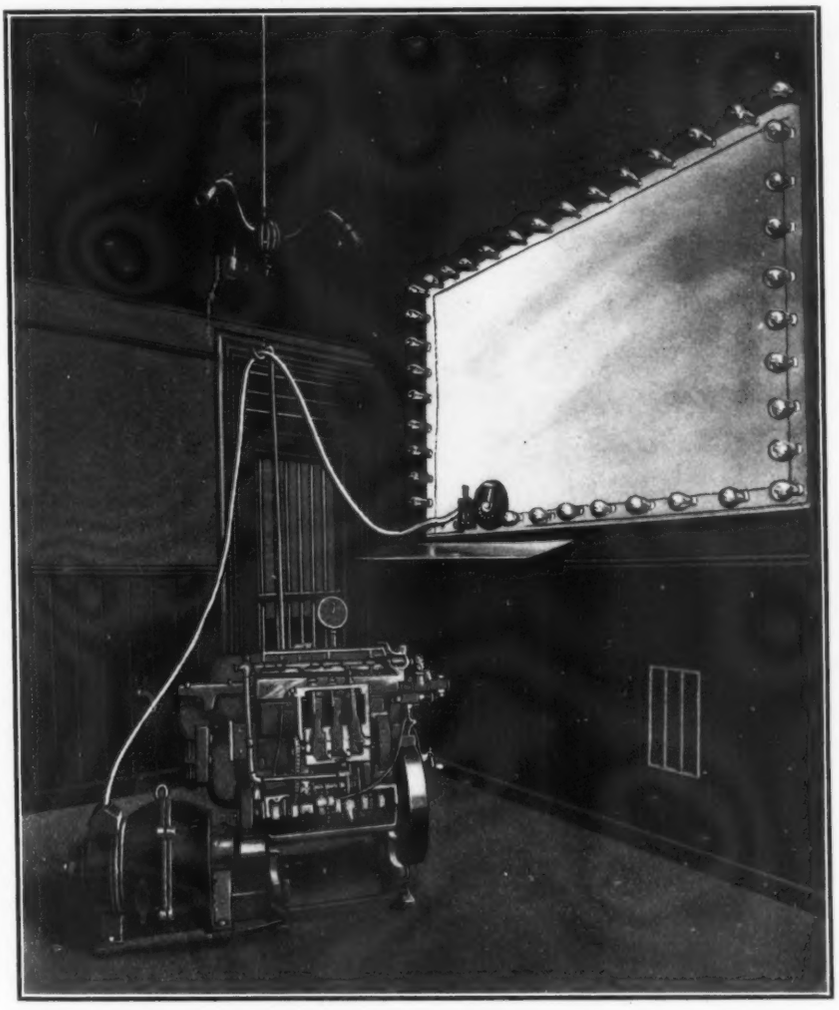
"Yes."

"Everybody get out of the room" he roared. "Clear the room Fred! Get me a long piece of string, I won't stay inside myself, I will go outside and pull it.—Do you realize what you are doing?"

We signified our willingness to "take a chance."

"Bring me that string! Tie it on those brushes.—No! I won't do it. It would be deliberate murder."

And broad smiles and winks went around the circle as the bluff fell flat.



THE CO_2 MOTOR AND APPARENT CONNECTIONS

We then suggested that if he objected to lifting the brushes he might disconnect one of the leads to the switch. "No! the effect would be the same. Bang! a thousand million pieces, because the load would be all removed from the engine." But he kept working the switch and throwing the load off and on without a flicker in the engine's speed. This he explained was because when he threw the switch the current went through the rheostat which was set to the same resistance as the lamps.

"But," remarked one of the observers, "the rheostat does not warm up and it has been taking the current for 41 lights for some minutes."

That, Mr. Carroll explained, was because it was made of the only metal in the world that would not heat up no matter how much electricity you put through it. He modestly announced it as one of his minor discoveries.

"Then if you turn the rheostat your engine will run faster, won't it?" asked the observer.

"Sure," replied the Sage, and with several quick moves of the handle he showed that the speed of the outfit was very positively under the control of the rheostat.

For automobile service a tank about as large as a good-sized cider jug is all that is required. No demonstration of this was given, except exhibiting the jug. "It enables us," the CO_2 Automobile Company, of Philadelphia, which is selling stock, not automobiles, states in its prospectus, "to construct a motor to generate 35 horse-power with all the accessories weighing not to exceed 175 pounds, at a cost of operation not exceeding 50 cents per month."

One of the automobile men present asked what would happen to an engine which would do such stunts when relieved of its load when it struck a down grade.

"Why, you would close your throttle."

"Well," it was asked, "why cannot you take off those brushes and stop the engine from running away with the throttle?"

"Because this is an 80 horse-power engine, capable of doing 300 horse-power with only two horse-power of lights on it. Where would it be, do you think, if the load were suddenly released by lifting those brushes?"

The engine consisted of three single-acting cylinders said to be 2 inches in diameter, 2¼ inches stroke and run at 160 revolutions per minute. Figure the mean effective pressure required to get 300 or even 80 horse-power out of it.

But the talk about the throttle put a bright idea into the head of an intelligent onlooker who had been saying nothing, but seeing it all.

"Ask him to close the throttle with the load on," he whispered.

We put the request.

"What do you think it will do?" demanded the Sage.

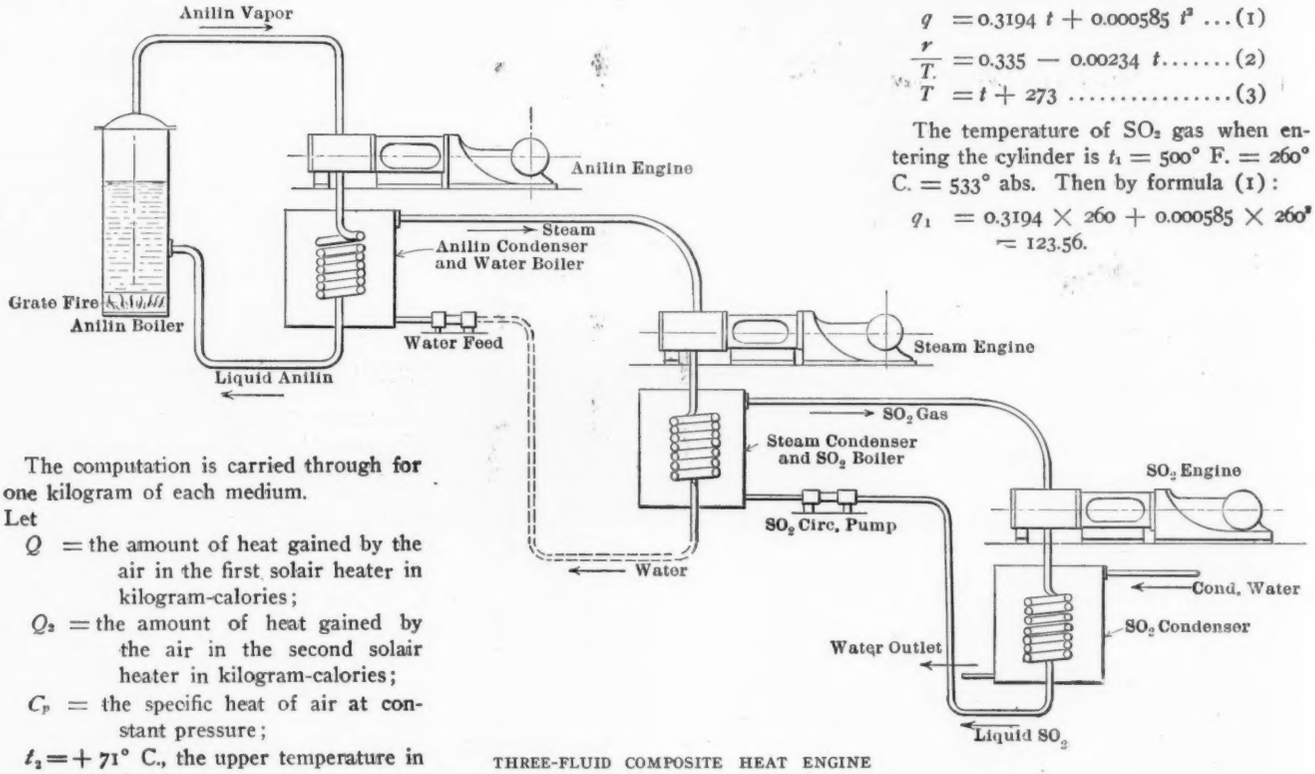
"I think the engine will keep on running as long as you have the switch closed between the board and that motor," we replied.

The Sage became rattled and abusive but absolutely refused to make this simple test, and we left with the conviction that while some of the promoters of these mechanical absurdities may be honestly mistaken, here was a scheme which could be nothing but a clumsy mechanical trick for obtaining money under false pretenses.

The Illusory Power System; Also One That Is Not Illusory

By C. F. Cukor

Referring to the illusory hot-air and sulphur-dioxide power system described in the June number of Power, it is easy to prove that the arrangement represents a thermodynamically balanced system; consequently no heat nor work can be gained therefrom. In order to prove this let us call the heat gained in the solair heaters +, the thermal equivalent of the work performed by the air expansive cylinder —, the thermal equivalent of the SO_2 power cylinder +, and the same equivalent of the work performed in the air compressor —. If the algebraic sum of said quantities is equal to zero, the initial contention will be proved.



THREE-FLUID COMPOSITE HEAT ENGINE

The computation is carried through for one kilogram of each medium.

Let

Q = the amount of heat gained by the air in the first solair heater in kilogram-calories;

Q_2 = the amount of heat gained by the air in the second solair heater in kilogram-calories;

C_p = the specific heat of air at constant pressure;

$t_2 = +71°$ C., the upper temperature in first heater;

$t_1 = +27°$ C., the lower temperature in first heater;

$t'_2 = +71°$ C., the upper temperature in second heater;

$t'_1 = -34°$ C., the lower temperature in second heater.

In both solair heaters the medium is heated at constant pressure, hence $C_p = 0.238$. The amount of heat introduced, $Q = Q_1 + Q_2$, is deduced thus:

$Q_1 = C_p (t_2 - t_1) = 0.238\ (71-27)$;

$Q_2 = C_p\ (t'_2 - t'_1) = 0.238\ [71 - (-34)\ ] = 0.238\ (71 + 34)$.

(I) $Q = Q_1 + Q_2 = 0.238\ (71 - 27 + 71 + 34) = +35.76$ kilogram-calories.

The thermal equivalent of the work done in the air-power cylinder can be ascertained in two steps; first, imagine the air is heated at a constant volume to compression temperature, and then compressed at constant temperature to final pressure. This requires the same amount of work or thermal units.

Let

t_1 = compression temperature = 160° F. or 71° C.;

t_2 = initial temperature = — 60° F. or — 51° C.;

p = the final pressure = 75 pounds = 34.3 kilograms;

R = gas constant = 29.27 for dry air;

C_v = specific heat of air at constant volume = 0.169 kilogram-calories;

Then:

$Q_1 = C_v (t_1 - t_2)\ 0.169 \times 122 = 19.518$, and

$Q_2 = \frac{1}{428} R\, t_1\, ln \frac{p_2}{p_1}$, where $\frac{1}{428}$ = the mechanical heat equivalent; $p_1 = 1$ kilogram in the present case;

$Q_2 = \frac{1}{428} \times 29.27 \times 3.52 = 16.25$ kilogram-calories.

(II) $Q = Q_1 + Q_2 = 19.518 + 16.25 = -35.76$ kilogram-calories.

The cycle in the air compressor can be figured in the same way:

$Q_1 = C_v\ (t_2 - t_1)$;

t_2 = 588° F = 309° C.;

t_1 = 160° F = 71° C.;

C_v = 0.169;

Q_1 = 40.46 kilogram calories;

$Q_2 = \frac{1}{428} R\, t\, ln \frac{p_1}{p_2} = 27.6$ kilogram-calories.

(III) $Q_1 + Q_2 = 40.46 + 27.6 = +68$ kilogram-calories.

The sulphur-dioxide power cycle may be considered the ideal one—engine without clearance and losses. Treating it as a Clausius cycle, the amount of work obtained is equal to the difference between the heat introduced and that extracted. If r represents the vaporization heat of sulphur dioxide and q = the liquefying heat, then $\lambda = q + r$ is the total energy of the medium; if λ_1 is the energy of the medium in thermal units (metric) before, and λ_2 after, performing the cycle, $\lambda_1 - \lambda_2 = Q$ will be equivalent to the work obtained. The indices "1" mark the initial values, and "2" the final ones in all cases.

According to experiments on SO_2

$q = 0.3194\ t + 0.000585\ t^2$ ...(1)

$\frac{r}{T} = 0.335 - 0.00234\ t$.....(2)

$T = t + 273$ .....(3)

The temperature of SO_2 gas when entering the cylinder is $t_1 = 500°$ F. = 260° C. = 533° abs. Then by formula (1):

$q_1 = 0.3194 \times 260 + 0.000585 \times 260^2 = 123.56$.

Tables not giving the value of r, let us figure it from formula (2):

$r = T\ (0.335 - 0.00234\ t)$;

$r_1 = 533\ (0.335 - 0.00234 \times 260) = -141.245$;

$\lambda_1 = q_1 + r_1 = 123.50 - 141.245 = -17.685$ kilogram-calories. (4)

For the final conditions:

$t_2 = 15.5°$ C. (60° F.);

$q_2 = 0.3194 + 15.5 + 0.000585 \times 15.5^2 = 5.13$;

$r_2 = (0.335 - 0.00234 \times 15.5)\ 288.5 = 86.5$;

$\lambda_2 = q_2 + r_2 = 5.13 + 86.5 =$ kilogram-calories. (5)

(IV) $\lambda_1 - \lambda_2 = 74$ kilogram-calories, from — to +, which can be done, as one is refrigeration and the other power.

Finally, as outlined in the beginning, comparing equations *I, II, III* and *IV*, it will be found that *I* cancels *II*, and *III* cancels *IV* (there is a slight discrepancy due to using table values, Centigrade temperatures in round numbers, etc.). Therefore, the system is in balance. It will be noted that the condensers drop out of the calculation, because the cycles are figured on conditions established by the condensers.

Talking about composite-medium power systems, it might be of interest to look up the really most efficient combination, shown in the accompanying sketch. Thermodynamics prove that the most efficient cycle is the one of Carnot, performed between two adiabatics and two isothermals. The expression of this efficiency is:

$$\eta = \frac{T_1 - T_2}{T_1},$$

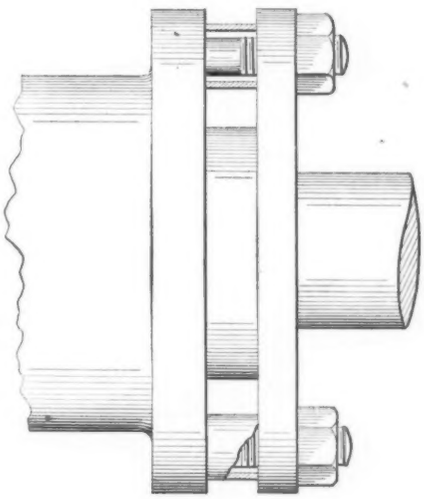
where T_1 is the upper temperature limit and T_2 the lower one. According to this the efficiency is dependent on the difference of temperatures through which the cycle is performed. In practice the upper temperature is limited by the initial pressure of the steam while the lower one is limited by the vacuum question and the large specific volume corresponding to low temperatures. To avoid mechanical difficulties, two mediums can be combined with the steam to carry out one power cycle, working between the highest and lowest possible temperature limits. Anilin has the property of low pressures at high temperatures; while sulphur dioxide has high pressure at low temperature and a small specific volume at atmospheric pressure.

The arrangement is this: Anilin is vaporized in a boiler and expanded in an engine, the exhaust of which serves to heat the water in the boiler of a steam engine. The boiler water condenses the anilin, which is fed back to the anilin boiler. This boiler is of common material, as the boiler pressure is not abnormal; only the temperature is high. The steam generated in the anilin condenser expands in a steam engine, is condensed by SO_2, cooled, and may be used again for feed-water as indicated by the dotted pipe line. The sulphur dioxide vaporized in the steam condenser works the SO_2 engine, and is condensed afterward. The efficiency of the whole system is high because T_1 is very high, and T_1 very low, consequently the amount of heat utilized is great. The system is subject, however, to the disadvantage of high first cost of the equipment.

Badly timed ignition seriously impairs gas-engine efficiency. If too early, power is wasted and moving parts are pounded; if too late, combustion is tardy and incomplete.

"A Packing and Temper Saver"

Under this caption a contributor to *The Engineer-in-Charge* presents the simple device illustrated herewith as a preventive of scored or fluted rods, bent glands and broken studs, caused by indiscriminate tightening of stuffing-box glands. The wrinkle, the author states, although not new, is not as widely known as it deserves to be. On reference to the self-explanatory sketch it will be seen that ferrules or distance pieces, consisting of short pieces of pipe surrounding the stud-bolts, are interposed between the stuffing-box and the follower gland, the ferrules being of such width as will suit the occasion. "Its object is obvious," the



A STUFFING-BOX DEVICE

writer concludes, "and the hint will doubtless be appreciated by those who have had 'trouble.'"

Relation of Heat Loss to Scale Thickness

The engineering experiment station of the University of Illinois recently issued a bulletin (No. 11) on "The Effect of Scale on the Transmission of Heat through Locomotive Boiler Tubes," by Edward C. Schmidt and John M. Snodgrass. This bulletin describes a series of experiments begun in 1900, to determine the relation of the heat loss due to scale to the scale thickness. The experiments comprised tests on single tubes as well as tests of the entire locomotive boiler.

The conclusions derived from the tests are summarized as follows: That for scale of thickness up to ⅛ inch the heat loss may vary in individual cases from insignificant amounts to as much as 10 or 12 per cent.; that the heat loss does increase with thickness in an undetermined ratio; that mechanical structure of the scale is of as much or more importance than thickness in producing this loss; that chemical composition, except in so far as it affects the structure of the scale, has no direct influence on heat transmissio

Awards for New Safety Devices

The work of the American Museum of Safety Devices, of which Dr. William H. Tolman is director, has received added impetus from without, three proposals having been made to bestow annual awards to stimulate the invention of safety appliances. The *Scientific American* offers a gold medal for the best device for the protection of life and limb produced during each year; Francis H. Richards, inventor, will give annually a gold medal for the best invention to be exhibited at the museum, the field of effort for this award to be limited to automobiles and motor boats; and Dr. L. L. Seaman has offered an annual prize for the best essay on the subject of safeguarding life by means of safety devices. These awards will be made upon representations of special boards of experts appointed by the executive committee of the American Museum of Safety Devices.

The accepted design for the *Scientific American* medal is one of three submitted. The medal will be 2⅜ inches in diameter and shows on the obverse the genius of invention rewarding the inventor of some device for saving the life of a factory operative, while a second allegorical figure conveys the supreme honor of a laurel wreath. On the jury for the award of this medal are included Prof. F. R. Hutton, president of the American Society of Mechanical Engineers, and Samuel Sheldon, president of the American Institute of Electrical Engineers.

As previously announced, the museum will occupy the entire third floor of the Thirty-ninth Street building, so called, New York City. Later, it is hoped, it will have a building of its own.

On July 30 a large fly-wheel at the Fort Wayne (Ind.) Pressed Brick Company's plant burst and wrecked the engine, as well as the engine room. The governor broke and the engine ran away. On August 5 two men were killed and four injured by the bursting of a flywheel at the plant of the Youngstown (O.) Iron and Steel Roofing Company. Neither plant was equipped with an independent safety-stop system.

A constructing engineer had a narrow escape from death at Hammond, Ind., one day recently. He fell from the top of a 200-foot chimney, but struck a projecting scaffold about 25 feet from the top, which enabled him to grasp a plank, thus saving his life.

Pressures and Work in a Gas Engine

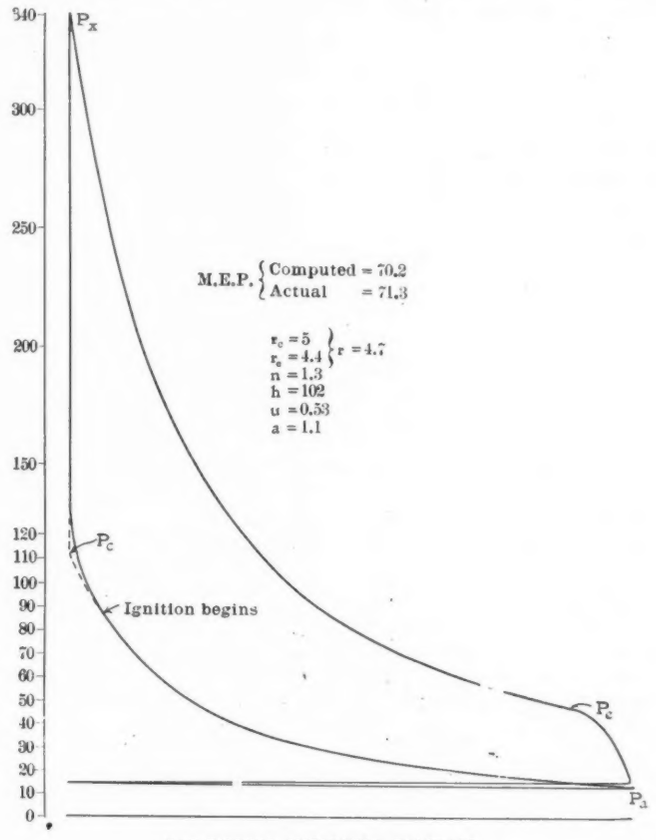
Formulas for Pressures Developed by Compression, Combustion and Expansion; Work, Horse-power and Mean Effective Pressure

BY CECIL P. POOLE

For the convenience of those who are interested in such matters, the accompanying formulas and equivalents applying to the compression, combustion and expansion of mixed gases have been collated and derived. Most of them can be found in print elsewhere if one has a sufficient collection of handbooks and text-books; the remainder have not hitherto been published, so far as the writer knows.

The symbols used herein and their meanings are as follows:

a = Volume of air ÷ volume of gas,
C_p = Specific heat of cylinder contents at constant pressure,
C_v = Specific heat of cylinder contents at constant volume,
c = Clearance volume ÷ piston displacement,
E_c = Increase of intrinsic energy by compression,
E_e = Decrease of intrinsic energy by expansion.
H = B.t.u. per pound of cylinder contents,
h = B.t.u. per cubic foot of gas,
N_x = Number of explosions per minute,
n = Average of compression and expansion curve exponents,
n_c = Exponent of compression curve equation,
n_e = Exponent of expansion curve equation,
P = Absolute pressure in pounds per square foot,
P_a = Pressure per square foot before compression,
P_c = Pressure per square foot after compression,
P_e = Pressure per square foot after expansion, i.e., when exhaust valve opens,
P_i = Pressure per square foot before expansion,
P_m = Mean pressure per square foot during a complete cycle,
P_{mc} = Mean pressure per square foot during compression,
P_{me} = Mean pressure per square foot during expansion,
P_x = Maximum pressure per square foot due to combustion (= P_i),
r = Average of compression and expansion ratios,
r_c = Compression ratio = $V_a \div V_c$,
r_e = Expansion ratio = $V_e \div V_i$,
T = Absolute temperature (Fahrenheit thermometer + 460),
T_a = Absolute temperature before compression,
T_c = Absolute temperature after compression,
T_e = Absolute temperature after expansion,
T_i = Absolute temperature before expansion,
T_x = Maximum absolute temperature due to combustion (= T_i),
u = Actual temperature rise produced by combustion ÷ temperature rise that would be produced by instantaneous adiabatic combustion,
V = Volume in cubic feet,
V_a = Volume of cylinder contents before compression,
V_c = Volume of cylinder contents after compression,
V_e = Volume of cylinder contents after expansion,
V_i = Volume of cylinder contents before expansion (= V_c),
V_s = Volume swept out by piston stroke (= $V_a - V_c$),
v = Cubic feet per pound of cylinder contents, uncompressed,
W = Net positive work of one cycle in foot-pounds,
W_c = Work of compression, in foot-pounds,
W_e = Work of expansion, in foot-pounds,
w = Weight of cylinder contents in pounds.



GAS-ENGINE INDICATOR DIAGRAM

The compression or expansion of air or sensibly perfect gases usually follows the law expressed by the equations:

$$P_1 V_1^n = P_2 V_2^n; \qquad (1)$$

and

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}. \qquad (2)$$

The subscript 1 indicates the state before compression or expansion and 2 indicates the state afterward.

Fundamental Compression Equations

If compression be adiabatic, or if heat be abstracted regularly during compression, the curve on the indicator diagram

will conform to equations (1) and (2). From those, the following have been derived:

$$V_c = V_a \div r_c. \quad (3)$$

$$V_c = V_a \div \left(\frac{P_c}{P_a}\right)^{\frac{1}{n}}. \quad (4)$$

$$V_c = V_a \div \left(\frac{T_c}{T_a}\right)^{\frac{1}{n-1}}. \quad (5)$$

$$P_c = P_a r_c^n. \quad (6)$$

$$P_c = P_a \left(\frac{T_c}{T_a}\right)^{\frac{n}{n-1}}. \quad (7)$$

$$T_c = T_a r_c^{n-1}. \quad (8)$$

$$T_c = T_a \left(\frac{P_c}{P_a}\right)^{\frac{n-1}{n}}. \quad (9)$$

$$n_c = \frac{log\ P_c - log\ P_a}{log\ r_c}. \quad (10)$$

$$n_c = \frac{log\ T_c - log\ T_a}{log\ r_c} + 1. \quad (11)$$

With adiabatic compression the value of n_c is also given by the equation:

$$n_c = C_p \div C_v. \quad (12)$$

The work of compressing air or gas is

$$W_c = \frac{P_c V_c - P_a V_a}{n_c - 1};$$

substituting the equivalents of V_c and P_c given in (7) and (8):

$$W_c = \frac{P_a V_a}{n_c - 1} \times (r_c^{n-1} - 1). \quad (13)$$

In terms of compression:

$$W_c = \frac{P_c V_c \left(1 - \frac{1}{r_c^{n-1}}\right)}{n_c - 1}. \quad (14)$$

Dividing by the piston displacement, the mean pressure during compression is

$$P_{mc} = \frac{P_a (r_c^{n-1} - 1)}{(n_c - 1)\left(1 - \frac{1}{r_c}\right)}, \quad (15)$$

or, in terms of the compression pressure:

$$P_{mc} = \frac{P_c \left(1 - \frac{1}{r_c^{n-1}}\right)}{(n_c - 1)(r_c - 1)}. \quad (16)$$

The increase in intrinsic energy in the working fluid due to compression is

$$E_c = 778\ C_v\ w\ (T_c - T_a),$$

and substituting the equivalent of T_c from equation (9):

$$E_c = 778\ C_v\ w\ T_a (r_c^{n-1} - 1). \quad (17)$$

The ratio of intrinsic energy increase to work of compressing is

$$\frac{E_c}{W_c} = \frac{n_c - 1}{\frac{C_p}{C_v} - 1}. \quad (18)$$

Fundamental Expansion Equations

With either adiabatic expansion or expansion during which heat is added regularly,

$$V_e = V_i r_e; \quad (19)$$

$$P_e = P_i \div r_e^n; \quad (20)$$

$$T_e = T_i \div r_e^{n-1}. \quad (21)$$

$$n_e = \frac{log\ P_i - log\ P_e}{log\ r_e}. \quad (22)$$

$$n_e = \frac{log\ T_i - log\ T_e}{log\ r_e} + 1. \quad (23)$$

With adiabatic expansion, the value of n_e is also given by the equation:

$$n_e = C_p \div C_v. \quad (24)$$

The work done by expanding air or gas is

$$W_e = \frac{P_i V_i - P_e V_e}{n_e - 1};$$

substituting the equivalents of V_e and P_e from equations (19) and (20),

$$W_e = \frac{P_i V_i}{n_e - 1}\left(1 - \frac{1}{r_e^{n-1}}\right). \quad (25)$$

In terms of final pressure and volume:

$$W_e = \frac{P_e V_e}{n_e - 1}(r_e^{n-1} - 1). \quad (26)$$

Dividing by the piston displacement during expansion ($V_e - V_i$), the mean pressure of the expanding fluid during the process is

$$P_{me} = \frac{P_i \left(1 - \frac{1}{r_e^{n-1}}\right)}{(n_e - 1)(r_e - 1)}, \quad (27)$$

or, in terms of release pressure:

$$P_{me} = \frac{P_e (r_e^{n-1} - 1)}{(n_e - 1)\left(1 - \frac{1}{r_e}\right)}. \quad (28)$$

The decrease in intrinsic energy in the working fluid due to expansion is

$$E_e = 778\ C_v\ w\ (T_i - T_e),$$

and substituting the equivalent of T_e from equation (21):

$$E_e = 778\ C_v\ w\ T_i \left(1 - \frac{1}{r_e^{n-1}}\right). \quad (29)$$

The ratio of intrinsic energy decrease to work done is

$$\frac{E_e}{W_e} = \frac{n_e - 1}{\frac{C_p}{C_v} - 1}. \quad (30)$$

The Gas-engine Cycle

The fundamental formulas for compression and expansion all apply to the gas-engine cycle, exception equations (12) and (24).

The clearance volume is equal to the volume after compression, so that

$$r_c = 1 + \frac{1}{c}, \quad (31)$$

and

$$c = \frac{1}{r_c - 1}. \quad (31\text{-a})$$

The rise of temperature due to combustion is equal to

$$\frac{Hu}{C_v};$$

so that the maximum temperature due to combustion is

$$T_z = T_c + \frac{Hu}{C_v}.$$

The factor u ranges from 0.4 to 0.6 in ordinary practice, values of 0.48 to 0.52 being common for indifferent mixtures of natural gas and air, and 0.54 to 0.58 being common for good mixtures of producer gas and air. Having an indicator diagram and knowing the calorific value of the gas, the value of u may be computed for the particular set of conditions under which the diagram was taken, thus:

$$u = \frac{(P_z - P_c)(1 + a)(1 + c)}{319\ h\ r_c}. \quad (32)$$

The heat units per pound of cylinder contents are

$$H = \frac{h\ v}{(1 + a)(1 + c)}.$$

The maximum temperature due to combustion, therefore, is

$$T_z = T_a r_c^{n-1} + \frac{h\ u\ v}{C_v (1 + a)(1 + c)}.$$

Since

$$\frac{v}{T_a} = \frac{778 (C_p - C_v)}{P_a},$$

$$\frac{v}{C_v T_a} = \frac{778 \left(\frac{C_p}{C_v} - 1\right)}{P_a};$$

and in practically all normal cases, $C_p \div C_v = 1.41$. Making the substitutions,

$$T_z = T_a \left(\frac{319\ h\ u}{P_a (1 + a)(1 + c)} + r_c^{n-1}\right). \quad (33)$$

The maximum pressure due to combustion is

$$P_z = P_c \frac{T_z}{T_c};$$

which expands, with substitutions, to

$$P_z = P_a r_c^n + \frac{319\ h\ u\ r_c}{(1 + a)(1 + c)}. \quad (34)$$

The rise of pressure above compression pressure, due to combustion, is $P_z - P_c$, and $P_c = P_a\ r_c^n$, hence

$$P_z - P_c = \frac{319\ h\ u\ r_c}{(1 + a)(1 + c)}. \quad (35)$$

The pressure at the moment when the exhaust valve opens is

$$P_e = \frac{P_z}{r_e^n},$$

the exponent n here being that of the expansion curve, of course. Assuming that the expansion and compression ratios are equal, which is never true; also assuming equality between the exponents of the expansion and compression curves, which is rarely true, and substituting the equivalent of P_z from equation (34), the release-pressure formula is

$$P_e = P_a \left(1 + \frac{319\ h\ u}{P_a r^{n-1} (1 + a)(1 + c)}\right). \quad (36)$$

Observing the distinction between the two ratios and exponents:

$$P_e = \frac{P_a}{r_e^n}\left(r_e^n + \frac{319\ h\ u\ r_e}{P_a(1+a)\ (1+c)}\right). \quad (37)$$

The temperature of the exhaust gases when released is

$$T_e = \frac{T_x}{r_e^{n-1}},$$

n being the exponent of the expansion curve. Assuming a common ratio of expansion and compression and a common exponent for the two curves, substituting the equivalent of T_x from equation (33) gives

$$T_e = T_a\left(1 + \frac{319\ h\ u}{P_a r^{n-1}(1+a)\ (1+c)}\right). \quad (38)$$

Recognizing the distinction between the expansion and compression ratios and exponents:

$$T_e = \frac{T_a}{r_e^{n-1}}\left(r_e^{n-1} + \frac{319\ h\ u}{P_a(1+a)\ (1+c)}\right). \quad (39)$$

Ignoring the small loss due to drawing in the charge, the positive work done during one cycle is

$$W = W_c - W_e;$$

and substituting the equivalents of W_c and W_e from equations (26) and (13), respectively, and the equivalents of P_e and V_e:

$$W = P_a V_a\left[\frac{\left(r_e^{n-1} + \frac{319\ h\ u}{P_a(1+a)\ (1+c)}\right)\left(1 + \frac{1}{r_e^{n-1}}\right) - \frac{r_e^{n-1}-1}{n_e-1}}{n_e - 1}\right] \quad (40)$$

Taking the average of the compression and expansion ratios as a common ratio and treating the exponents similarly, an approximate equation may be derived as follows:

$$W = \frac{319\ V_a\ h\ u\left(1 - \frac{1}{r^{n-1}}\right)}{(1+a)\ (1+c)\ (n-1)}. \quad (41)$$

Dividing by the piston displacement, $V_a \div (1+c)$, the mean effective pressure of the cycle, per square foot is

$$P_m = \frac{319\ h\ u\left(1 - \frac{1}{r^{n-1}}\right)}{(1+a)\ (n-1)};$$

and the mean effective pressure per square inch is

$$p_m = \frac{2.2\ h\ u\left(1 - \frac{1}{r^{n-1}}\right)}{(1+a)\ (n-1)}. \quad (42)$$

The indicated horse-power is

$$H.P. = \frac{W\ N_x}{33{,}000},$$

and taking the equivalent of W given by equation (41):

$$H.P. = \frac{V_s\ N_x}{42.4} \times \frac{h\ u\left(1 - \frac{1}{r^{n-1}}\right)}{1+a} \times \frac{\frac{C_p}{C_v} - 1}{n-1},$$

or

$$H.P. = 0.00965\ V_s\ N_x \frac{h\ u\left(1 - \frac{1}{r^{n-1}}\right)}{(1+a)\ (n-1)} \quad (43)$$

Examination for a First-class Engineer's License

A Massachusetts correspondent sends the two lists of questions following, with a request for the answers, explaining that they were asked of him by the State examiner while determining his eligibility for a first-class license. The answers follow each set of questions.

Engine

Horizontal cross-compound condensing engine, of 2000 horse-power nominal capacity.

1. Give the approximate dimensions of each cylinder.
2. Number of revolutions per minute.
3. Size of pulleys on engine and shafting to produce shaft speed of 400 revolutions per minute.

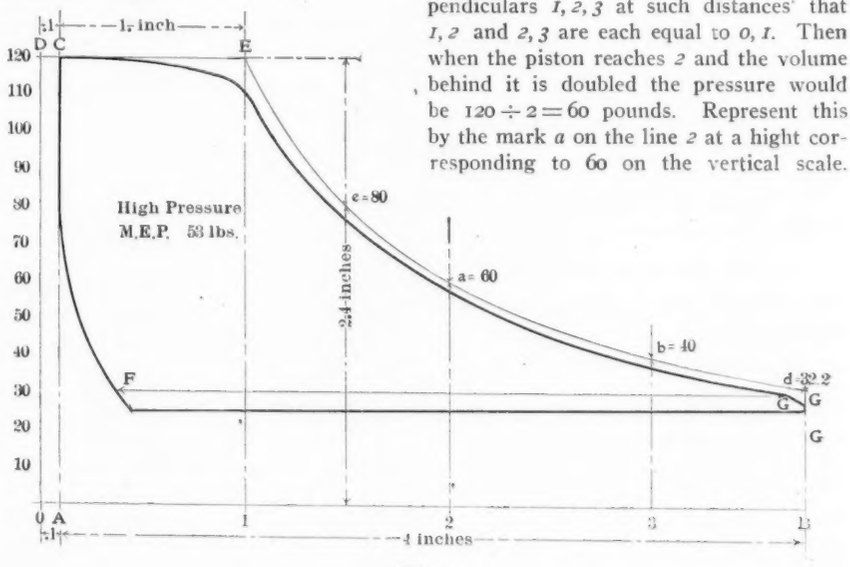


FIG. 1

4. Give the initial pressure of each cylinder.
5. Give the terminal pressure of each cylinder.
6. Give the mean effective pressure of each cylinder.
7. Give the point of cut-off for economy.
8. Draw an approximately theoretic card of each cylinder, for economy.
9. Draw some cards with the admission late—one-sixteenth of stroke.
10. Calculate the horse-power of each cylinder from the cards you make.

Answers

The mean effective pressure available is one of the principal factors in determining the size of the engine. This will be determinable from the indicator diagrams, and since these are required anyway it will be well to approach the problem from that direction.

Let us assume an initial pressure of 120 pounds absolute, 105 gage, which would require a boiler pressure of some 110 pounds.

Draw the line $A\ B$, Fig. 1, four inches long, to represent the stroke, and the line $A\ C$ $120 \div 50 = 2.4$ inches high, to represent 120 pounds pressure on a scale of 50 to the inch. Assume the clearance in the high-pressure cylinder to be 2½ per cent., and draw the line $O\ D$ distant $0.025 \times 4 = 0.1$ of an inch from $A\ C$, so that $O\ A$, being 2.5 per cent. of $A\ B$, will represent that clearance. Draw $C\ E$ one inch in length to represent the travel of the piston up to one-quarter stroke, where we will assume the cut-off to take place in the high-pressure cylinder. Then at the point of cut-off there will be a volume of steam proportional to $D\ E$ ready to expand behind the piston.

In the ordinary cylinder when the volume is doubled the pressure is approximately halved; when the volume becomes three times the original the pressure becomes about one-third, etc. Erect the perpendiculars *1, 2, 3* at such distances that *1, 2* and *2, 3* are each equal to *0, 1*. Then when the piston reaches *2* and the volume behind it is doubled the pressure would be $120 \div 2 = 60$ pounds. Represent this by the mark *a* on the line *2* at a hight corresponding to 60 on the vertical scale. At *3* the pressure will be $120 \div 3 = 40$ pounds, represented by *b*. Additional points may be put in if desired as at *c*, where the volume is 1½ and the pressure

$120 \div 1\frac{1}{2} = 80$ pounds, and the pressure at the end of the stroke d will be $170 \times \frac{11}{41} = 32.2$ pounds, because $DE = 1.1$ inches and $OB = 4.1$ inches. Connecting these points by a smooth curve the ideal expansion line is obtained.

Allowing for wire-drawing, compression, etc., we might expect to get some such diagram as that sketched inside the ideal lines.

If the compression line is as drawn there will be a volume proportional to the line

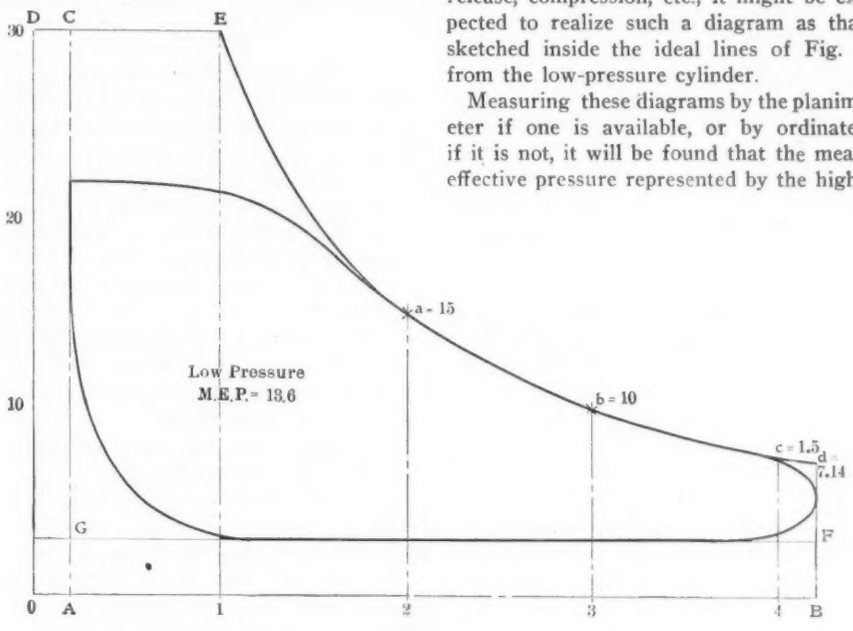


FIG. 2

FG (3.6 inches) of steam of 30 pounds pressure delivered to the low-pressure cylinder.

Draw the line AB, Fig. 2, four inches in length to represent the stroke of the low-pressure piston, and erect the line AC three inches high to represent 30 pounds on a 10-pound scale. Suppose the clearance of the low-pressure cylinder to be 5 per cent., and erect the line OD $0.05 \times 4 = 0.2$ of an inch from AB, to bound that clearance. Assume that the diameter of the low-pressure piston is twice that of the high-, in which case its area will be four times that of the high-, and each foot of movement of the low-pressure piston will generate four times the volume of a similar movement of the high-. A unit of length in Fig. 2, then, represents four times as much volume as in Fig. 1, and the 3.6 inches of volume represented by FG in Fig. 1 would fill Fig. 2 only up to $3.6 \div 4 = 0.9$ of an inch. As we shall fill the low-pressure clearance by compression to about one-half the initial, we will consider it half filled with initial steam and lay out the initial volume $DE =$ one inch (0.1 for the steam left in the clearance and 0.9 for that delivered from the high-pressure cylinder).

Erect the ordinates at *1, 2, 3, 4* and lay out the expansion line as before, the pressures for a, b, c, etc., being found by dividing the initial pressure 30 by the number of the ordinate, and the terminal pressure d by taking 10/42 of 25; for the initial volume DE is 10/42 of the final volume OB.

Assume the vacuum in the cylinder to be 24 inches, or an absolute back pressure of 3 pounds, and draw in the line FG, to represent that back pressure; then the ideal low-pressure diagram is $CEdGF$.

Allowing for three pounds loss between the counter-pressure line of the high-, and the initial pressure of the low-, also for release, compression, etc., it might be expected to realize such a diagram as that sketched inside the ideal lines of Fig. 2 from the low-pressure cylinder.

Measuring these diagrams by the planimeter if one is available, or by ordinates if it is not, it will be found that the mean effective pressure represented by the high-pressure diagram is 53 and that by the low- is 13.6 pounds. Since the low-pressure piston has four times the area of the high-, it would take only one-quarter the pressure to have the same effect when exerted upon the greater as upon the smaller piston. A mean effective pressure of $\frac{53}{4} + 13.6 = 26.85$ pounds acting in the low-pressure cylinder alone would have the same effect as the two M. E. P. given working in their respective cylinders.

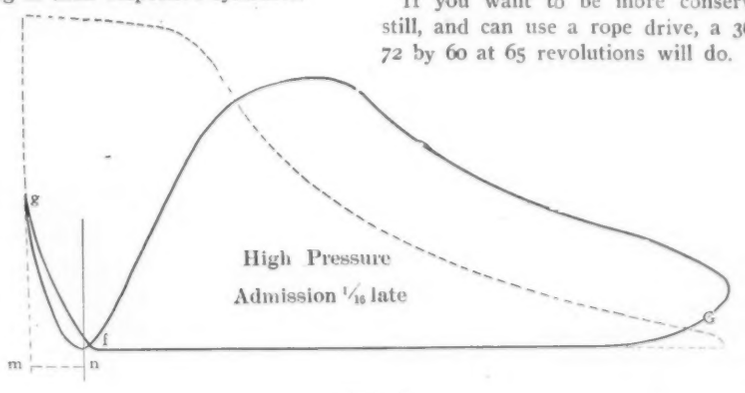


FIG. 3

To turn a shaft 400 revolutions per minute with one reduction an engine ought to run at a pretty good rotative speed; if not, there will be too great a difference between the diameter of the driver and driven pulleys. If it runs at 100 revolutions the driver will be four times the diameter of the driven, and this ratio ought not to be exceeded if it can be avoided. Unless the stroke is made unnaturally short, the piston speed will be high. Let us try it at 800 feet per minute.

The horse-power of an engine is:

$$H.P. = \frac{M.E.P. \times area \times piston\ speed}{33{,}000},$$

then

$$Area = \frac{33{,}000 \times 2000}{M.E.P. \times piston\ speed}.$$

Call the M. E. P. in round numbers 26 pounds, use 800 feet of piston speed, and the area of the low-pressure cylinder for an engine to develop 2000 horse-power would be:

$$Area = \frac{33{,}000 \times 2000}{26 \times 800} = 3173\ sq.in.$$

As the area is $0.7854 \times$ the square of the diameter,

$$D^2 = \frac{area}{0.7854} = \frac{3173}{0.7854} = 4040\ sq\ in.$$

Then D must be between 60 and 70, for $60^2 = 3600$ and $70^2 = 4900$. It is really 63.56. The applicant can locate it about 64 by a couple of trials if he cannot do square-root. If books of reference are available, a table of areas will give the nearest diameter at once, and it would be 64. To run 100 revolutions per minute and make 800 feet of piston speed the engine would have to make 8 feet per revolution or 4 feet per stroke. A 32 and 64 by 48-inch engine running at 100 revolutions will do.

If you want to be more conservative on speeds and put your belts to a disadvantage you can use a ratio of 5 instead of 4, making the engine speed 80 revolutions. This with a 54-inch stroke would give you 720 feet of piston speed, requiring an area of

$$\frac{33{,}000}{26 \times 720} = 3526\ sq.in.,$$

which would require a 67-inch cylinder, and to stay in standard sizes we might use a 34 and 68 by 54.

If you want to be more conservative still, and can use a rope drive, a 36 and 72 by 60 at 65 revolutions will do. Any of these engines would be practicable. The designer would be governed by service and conditions.

The rim velocity of the pulleys, if ordinary cast-iron wheels are used, must not exceed a mile, or 5280 feet a minute. Since the circumference is $3.1416 \times$ diameter,

the speed = 3.1416 × diameter × revolutions. Putting the rim speed at 5280 feet per minute, the diameter of a wheel making 400 revolutions would be

$$Diameter = \frac{5280}{3.1416 \times 400} = 4.2 \text{ feet.}$$

Say, then, to keep to even figures, that we use a 4-foot driven pulley. The pulley of the engine which runs at 65 revolutions per minute would have to be $\frac{400 \times 4}{65} = 24.6$ feet, that of the engine running at 80 revolutions $\frac{400 \times 4}{80} = 20$ feet, and that at 100 revolutions $\frac{400 \times 4}{100} = 16$ feet.

To answer the questions, now, in their order:

1. High-pressure, 32x48, 34x54, or 36x60; low-pressure, 64x48, 68x54 or 72x60.

2. Revolutions per minute, 65, 80 or 100, respectively.

3. Engine pulley. 24.6 feet, 20 feet or 16 feet; shaft pulley, 4 feet.

4. Initial pressure: High-pressure, 120; low-pressure, 22 pounds absolute.

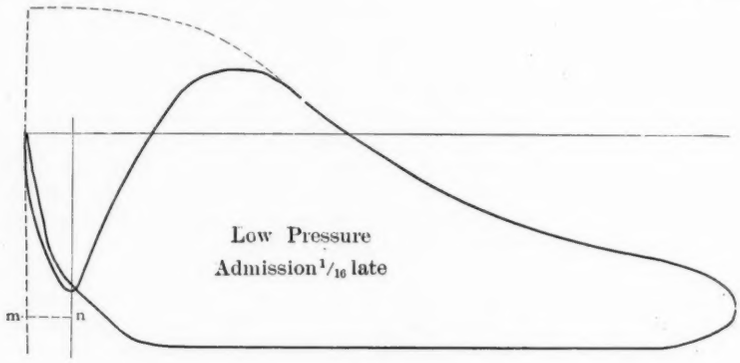


FIG. 4

5. Terminal pressure: High-pressure cylinder, 32.2; low-pressure cylinder, 7.14 pounds absolute, assuming initial pressure expanded to end of stroke. (See diagrams.)

6. M. E. P.: High-pressure cylinder, 53; low-pressure, 13.6 pounds per square inch.

7. One-quarter stroke.

9. The distance *m n*, Figs. 3 and 4, is 1/16 of the length of the diagram. (That is, it was intended to be, but owing to a mistake on the part of the engraver, the distance *m n*, Fig. 3, is more than that. It does not greatly alter the character of the result, however.) If the steam valve does not open for admission until the piston reaches *n* on the backward strokes, the steam in the clearance will re-expand, not along the line *f g* of its compression, but below that line, on account of the transfer of heat to the iron and leakage, making some such loop as shown. When the valve is finally opened, the pressure does not rise at once to the full amount as the piston has got in motion, but drags upward as shown, and the cut-off is enough later to keep the area the same. If this occurred in the low-pressure cylinder it would modify the diagram only as shown by the dotted lines, the expansion line being determined by the amount of steam delivered by the high-pressure cylinder.

10. $$H.P. = \frac{PLAN}{33{,}000}.$$

$P =$ { High-pressure, 53 pounds per square inch. Low-pressure, 13.6 pounds per square inch.

$L =$ 4, 4.5 and 5 feet, respectively.

$A =$ { High-pressure, 804.25, 907.92, 1017.9. Low-pressure, 3217, 3631.7, 4071.5

$N =$ 200, 160 and 130 strokes per minute, respectively.

High-pressure H. P. =

$$\frac{53 \times 4 \times 804.25 \times 200}{33{,}000} = 1077$$

Low-pressure H. P. =

$$\frac{13.6 \times 4 \times 3217 \times 200}{33{,}000} = 1061$$

Total, 2138

High-pressure H. P. =

$$\frac{53 \times 4.5 \times 907.92 \times 160}{33{,}000} = 1050$$

Low-pressure H. P. =

$$\frac{13.6 \times 4.5 \times 3631.7 \times 160}{33{,}000} = 1078$$

Total, 2128

High-pressure H. P. =

$$\frac{53 \times 5 \times 1017.9 \times 130}{33{,}000} = 1063$$

Low-pressure H. P. =

$$\frac{13.6 \times 5 \times 4071.5 \times 130}{33{,}000} = 1076$$

Total, 2139

showing that either engine is amply large for the work, and that the work is well distributed between the cylinders.

Boilers

1. Describe a Babcock & Wilcox water-tube boiler.

2. How are the tubes secured at the ends?

3. What means are provided for cleaning them?

4. What kinds of joints are there in a Babcock & Wilcox boiler?

5. How are the tube sections connected to the steam sections?

6. Describe the form of the steam section of the Babcock & Wilcox boiler.

7. How are the steam sections stayed or braced?

8. How does the water circulate in a Babcock & Wilcox boiler?

9. How and to what is the water column attached at the bottom and top ends?

10. Describe a baffle-plate in a Babcock & Wilcox boiler, where it is located, and why it is used.

Answers

1. A Babcock & Wilcox boiler consists of tubes usually 4 inches in diameter and 14 to 18 feet long connected into headers, generally in sets of nine and set in an inclined position at about 15 or 20 degrees from the horizontal underneath a steam drum or drums to which the headers are connected at the front and rear.

2. The tubes are expanded into the headers.

3. A hand-hole is provided opposite each end of each tube so that a cleaner may be run through. Manholes provide access to the steam drums.

4. Riveted joints and expanded joints.

5. By expanded nipples.

6. A plain cylindrical shell with bumped ends.

7. They need no bracing nor staying.

8. From the front to the back of the drum, down the back connections, forward and upward through the tubes.

9. At the top of the steam drum, the connection being made to the top of the drum or steam space; at the bottom either to the bottom of the steam drum or to the front header.

10. A baffle-plate is a plate of fire-brick or other refractory material interposed between the tubes so as to form with others a curtain or partition at right angles to the tubes. Such a partition is usually located above the bridgewall and another half way between the first and the rear headers. Their purpose is to compel the gases to make three passes across the bank of tubes.

There is also a baffle-plate in the steam drum to deflect the rising current of steam and water backward.

At the recent meeting of the American Society of Mechanical Engineers, at Indianapolis, during the discussion on superheated steam, the change of shapes of cast-iron fittings subjected to superheated steam of high temperature was mentioned. An instance has come to our attention where a cast-iron tee 35 inches long increased in length ¾ of an inch after a use of several months. The pressure was 170 pounds, and the degree of superheat 125 degrees, so that the temperature should have been 500, but the probability is that it got considerably in excess of this to produce the effect described.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Bending Stress in Connecting-rod Caps

Referring to the accompanying figure it will be seen that the upper part of the connecting-rod cap is subject to a bending stress. At A the bending moment lies between $\frac{Pl}{4}$ and $\frac{Pl}{8}$ depending in amount upon the degree to which the cap may be considered a beam fixed or simply supported at the ends. Ordinarily a bending moment midway between the two extremes may be used, i. e.,

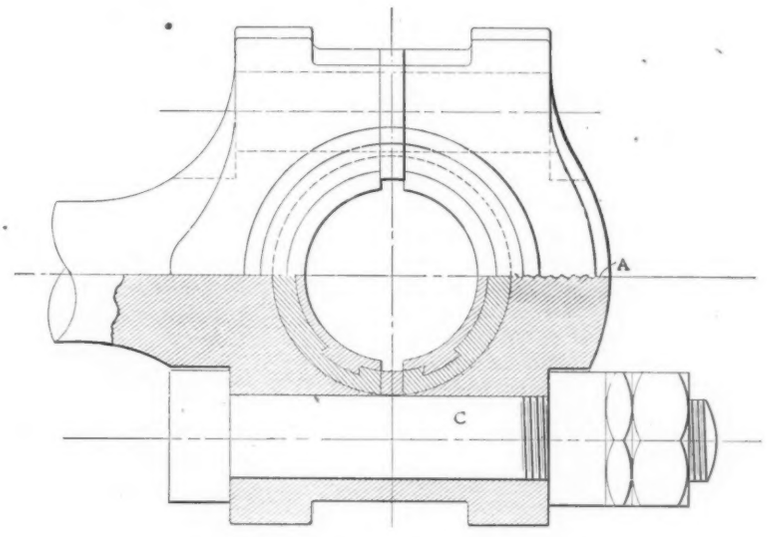
$$B.\ M. = \frac{Pl}{6}.$$

This gives satisfactory results. This bending stress in the cap gives rise to a state of affairs which, while negligible in the case of a small engine, must be fully considered in the design of a large engine.

It is not sufficient that the cap be made strong enough to eliminate all danger of its breaking. In addition to this the deflection at A must be practically zero. This is evident since it is clear that any deflection at A will produce a bending stress in the bolt C in addition to the tension for which it is designed. This bending moment is equal to $P_1 L_1$, when P_1 equals the horizontal component of the stress in the cap due to deflection, and L_1 equals the leverage of P_1. As a result of this bending moment on one side of bolt C we have a stress equal to the difference between the normal bolt tension and the compression due to bending, and on the other side of the bolt there is a tensional stress equal to the normal bolt tension plus the tension from the bending action.

Let us assume an engine making 300 revolutions per minute, with a connecting-rod so designed as to give a small deflection at A. In this case the bending moment in bolt C changes 300 times each minute from zero to a maximum. Then 300 times per minute on one side of the bolt we have a tension below, and on the other side tension above, the normal. What might be called the foreign stresses introduced are not large, and it is not inconceivable that the resultant stress on the compression side of the bolt will ever be compression, and the additional tension upon the tension side is not large enough in itself to produce rupture. The only danger is from the repeated and rapid changes in the combined stresses and this frequently causes rupture through the fatiguing of the metal of the bolt.

The writer has in mind a case in which the connecting-rod bolt of an engine broke repeatedly, even though the rods were replaced by much larger ones. After having broken the largest bolts the construction and size of the cap would allow, a more complete search was made for the cause of the trouble and it was found that the cap allowed of considerable deflection. By increasing the area at A the breaking of the bolts was stopped.



BENDING STRESS IN CONNECTING-ROD CAPS

T. R. SIMONS.

Detroit, Mich.

What Holds the Chimney Up?

The accompanying cut represents a cross-section of a brick chimney, the inner flue being 6½ feet in diameter, the flue leading from the boiler 5 feet wide and 8½ feet high, or large enough to supply all the gases the chimney will take care of. The walls were 12 inches thick and contained six buttresses, 12 wide, reaching to within 2 inches of the inner flue. The flue from the boilers was arranged so that one buttress would come directly in the center of the arch over the flue (not shown in cut).

WHAT HOLDS THE CHIMNEY UP?

It became necessary to connect another boiler to this chimney, and the engineer instead of putting a flue from the new boiler into the flue of the older boilers, cut another hole in the chimney at right angles to the old one, cutting through two of the buttresses, etc., as shown by the dotted line. He made the hight of the flue the same as the old one, making the entrance to the chimney double the amount the chimney can care for. The question is, what holds the chimney up? Fortunately, it stands right under a hill, with woods pretty well surrounding it, so that it is fairly well protected from strong wind.

W. E. CRANE.

Boston, Mass.

Long Steam Coils Undesirable

Frequently I have seen in engineering papers illustrations of steam coils built similarly to one presented by H. Jahnke in a recent article on piping (May POWER, page 297, Fig. 9). Now, while I dislike to "knock," as the saying is, I feel that I ought to advise green engineers that a long coil built without a corner turn of at least two feet is sure to give trouble, the turn being required to compensate for the extra length when steam is turned on.

JAMES E. NOBLE.

Toronto, Ont.

"Effect of Compression on Cut-off"

I have just noticed W. E. Crane's letter on this subject, in the June number, page 388. We are in agreement, it seems, but for the one fact that I undertake to explain the cause of the effect which we both acknowledge the existence of. That the cut-off corner becomes rounded when compression is high we admit, but I have gone farther and have tried to explain why it is so.

I believe now that I can make myself clear on this point by saying that the sharpness of the cut-off corner depends upon the relative quickness of the closure of the admission port by the valve, and the speed at which the piston is moving at the time cut-off occurs. We know that the speed of port closure is fixed if the port opening is full, but the speed of the piston is greater toward the middle of the stroke than it is toward the end of the stroke. Then if cut-off occurs later, the piston is nearer mid-stroke, is consequently moving at greater speed, and will move farther while the valve is closing the port than when cut-off occurs earlier while the piston is moving more slowly.

Again, as compression is increased to the point where it acts as a brake on the engine, the load is increased, the cut-off will be later, and for this reason the cut-off corner will be more rounded than when cutting off earlier in the stroke. I believe Mr. Crane will agree with me that this is the only logical solution of the problem.

WILLIAM WESTERFIELD.

Charleston, Mo.

"Formulas for the Flow of Steam in Pipes"

I read with great interest Professor Gebhardt's very valuable article in June POWER on "The Flow of Steam in Pipes," where he tells us how to find the probable fall in pressure along a steam line for different deliveries and for different-sized pipes. I think it is usually of interest and often of importance to know not only this but also the probable energy efficiency of the line, so as to know what part of the power from the boiler will likely reach the engine. Especially is this so where the line is very long—a mile long for example—where the question may be, "Will it pay at all to pipe steam so far, or will line losses be too great?"

In what follows I attempt to show how this efficiency may be computed. Plainly this efficiency is the ratio of the available heat at the end of the line to that which would be available at the beginning of the line. The heat per pound of steam which would be available at the beginning of the line is λ_1 (the total heat in 1 pound of dry steam at the pressure p_1), and the heat which is available at the end of the line is $x\ \lambda_2$ (x = fraction of steam uncondensed by the time steam reaches the end of the line and λ_2 = total heat in 1 pound of dry steam at the end of the line), so that the efficiency is $x\ \frac{\lambda_2}{\lambda_1}$; λ_1 and λ_2 may be taken directly from steam tables as soon as p_1 and p_2 (the respective pressures) are known. One pressure is assumed, and the other computed by one or other of the formulas given by Professor Gebhardt.

To find x let wk equal the foot-pounds of work done against friction per pound of entering steam in forcing the steam through the line; and let ht equal the heat leakage in B.t.u. per pound of entering steam. Then we may write:

$$\lambda_1 - \frac{w\,k}{778} - h\,t = q_2 + x_2\,r_2,$$

where q_2 = heat of the liquid and r_2 = heat of vaporization, so that

$$x = \frac{\lambda_1 - \frac{w\,k}{778} - h\,t - q_2}{r_2},$$

in which wk and ht are the only quantities unknown.

The work done against friction is equal to the pounds of steam passing times the lost head measured in feet of steam; the lost head is equal to the lost pressure in pounds gage × 144 × volume in cubic feet of 1 pound of steam, that is, to $(p_1 - p_2)144S$; so that wk or the work per pound is simply equal to the lost head, that is, to $(p_1 - p_2)144S$, and substituting this in the above value for x we have:

$$x = \frac{\lambda_1 - \frac{144\,(p_1 - p_2)\,S}{778} - h\,t - q_2}{r_2},$$

or

$$x = \frac{\lambda_1 - 0.1851\,(p_1 - p_2)\,S - h\,t - q_2}{r_2},$$

in which ht is the only unknown quantity.

Heat flow is very like electric flow. Difference in temperature corresponds to difference in voltage, and heat resistance to electric resistance. Ohm's law for electric flow, $C = \frac{E}{R}$, becomes with heat flow

$$C_1 = \frac{(T_1 - T_2)}{R^1},$$

where C^1 is heat units per second and $T_1 - T_2$ is the difference in temperature between the points considered and R^1 is the heat resistance between these points.

Heat resistance, like electric resistance, varies directly with the length of flow and inversely with the area of flow; it also, like electric resistance, varies with the substance of the conductor. I believe that it is usual to give specific conductivity rather than specific resistance, and to give it in c.g.s. units, that is, in gram calories per second per square centimeter for each degree Celsius fall in temperature per centimeter. Specific conductivity is the reciprocal of specific resistance and is usually designated by the letter k.

It is easily derived from the fundamental formula, gram calories per second = difference in degrees Celsius ÷ by the total heat resistance,

$$\text{or } C^1 = \frac{T_1 - T_2}{R^1},$$

that for a straight pipe with single insulation:

B.t.u. leakage per second =

$$0.2111\,l\,(T_1 - T_2)\,k\left(1 + \frac{d}{t}\right),$$

or

Boiler horse-power leakage per second =

$$0.0228\,l\,(T_1 - T_2)\,k\left(1 + \frac{d}{t}\right),$$

and for straight pipe with double insulation (one insulation outside of another):

B.t.u. leakage per second =

$$\frac{0.2111\,l\,(T_1 - T_2)}{\frac{t}{k\,(d + t)} + \frac{t^1}{k^1\,(d + 2\,t + t^1)}},$$

or

Boiler horse-power leakage per second =

$$\frac{0.0228\,l\,(T_1 - T_2)}{\frac{t}{k\,(d + t)} + \frac{t^1}{k^1\,(d + 2\,t + t^1)}},$$

where

l = Length of pipe in feet,

$T_1 - T_2$ = Difference in temperature in degrees Fahrenheit between the surface of the pipe and the outer surface of the insulation,

d = Outer diameter of pipe in inches,

t and t^1 = Thickness in inches of the inner and outer insulations, respectively,

and

k and k^1 = the specific conductivities in c.g.s. units of the inner and outer insulations.

Now $h\,t$ = B.t.u. leakage per second divided by pounds per second; and if pounds

per second $= w$, our value for x becomes:

$$x = \frac{\lambda_1 - q_2 - 0.1851\,(p_1 - p_2)\,S - \dfrac{0.2111\,l\,(T_1 - T_2)\,k\left(1 + \dfrac{d}{l}\right)}{w}}{r_2}.$$

In this expression T_1 may be taken as the temperature of the steam and T_2 either guessed at or else determined experimentally; T_2 will be always greater than the temperature of the steam and T_2 either

It will be noted that while the friction loss only takes place when steam is being used that the heat-leakage loss goes on all the time, and at about the same rate independently of whether or not steam is being used.

To illustrate the use of the foregoing by a concrete example let us suppose that it is desired to pipe steam 2700 feet through a 7-inch pipe (outer diameter of pipe 7.9 inches), the pipe to be insulated by 2¾ inches of light porous calcined magnesia ($k = 0.00016$); that the pressure at the boilers (p_1) equals 100 pounds gage; that it has been found experimentally that the outside of the insulation will just feel warm to the hand, the temperature assumed to be 100 degrees Fahrenheit. It is required to know:

1. What will be the drops in pressure along the line for different boiler horse-power?
2. What will be the fractions of steam uncondensed along the line for different boiler horse-power?
3. What will be the rates of total condensation along the line for different boiler horse-power?
4. What will be the line efficiencies for different boiler horse-power?
5. What will be the line losses for different boiler horse-power?

1. The drop in pressure along the line is found by means of one or other of the formulas given by Professor Gebhardt. Making the usual assumption of 30 pounds of water per hour per boiler horse-power, Babcock's formula

$$w = 87\sqrt{\frac{w\,(p_1 - p_2)\,d^5}{L\left(1 + \dfrac{3.6}{d}\right)}}$$

reduces in this case to

$$p_1 - p_2 = 0.0000311\ H.P.^2,$$

in which $H.P.$ is boiler horse-power entering the line.

2. The fraction of steam uncondensed by the time it reaches the end of the line x is given by the equation:

$$x = \frac{\lambda_1 - q_2 - 0.1851\,(p_1 - p_2)\,S - \dfrac{0.2111\,l\,(T_1 - T_2)\,k\left(1 + \dfrac{d}{l}\right)}{w}}{r_2},$$

which in this case reduces to

$$x = \frac{1185 - q_2 - 0.1851\,(p_1 - p_2)\,S - \dfrac{0.3532\,(T_1 - 100)}{w}}{r_2},$$

or

$$x = \frac{1185 - q_2 - 0.1851\,(p_1 - p_2)\,S - \dfrac{42.38\,(T - 100)}{H.P.}}{r_2}$$

In this equation S and T may be taken as the specific volume, and temperature of steam at the mean pressure

$$\frac{p_1 + p_2}{2}.$$

3. The rate of condensation in pounds per minute $=$

$$\frac{H.P.}{2}\,(1 - x).$$

4. The line efficiency $= x\,\dfrac{\lambda_2}{\lambda_1}$.

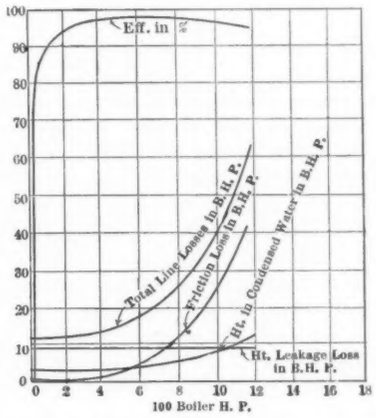
5. The line losses may be divided into three:

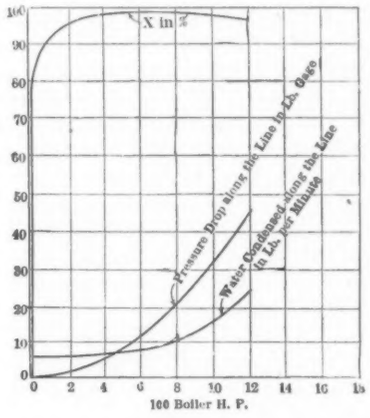
(a). Heat leakage $=$ $0.0228\,l\,(T_1 - T_2)\,k\,(1 + \dfrac{d}{l})$ *boiler horse-power.*

(b). Friction loss $=$ $0.0001667\ H.P.\,(p_1 - p_2)\,S$ *boiler horse-power.*

(c). Condensation loss $=$ $0.0009\ q_2\ H.P.\ (1 - x)$ *boiler horse-power.*

These three formulas are general.





CURVES SHOWING EFFICIENCY, LOSSES, CONDENSATION, ETC., OF HYPOTHETICAL STEAM LINE AT DIFFERENT BOILER H.P.

In the example taken (a) reduces to:

Heat leakage $= 0.03815\ (T - 100)$ *boiler horse-power;*

and (b) reduces to:

Friction loss $= 0.00000000518\ H.P.^3 S$ *boiler horse-power;*

while (c), the heat still remaining in the condensed water, cannot be further reduced.

In conclusion I want to draw attention to the accompanying curves for the hypothetical case taken which, among other things, strikingly illustrate the high efficiencies obtainable from properly insulated steam lines, even though the lines are very long. It will be observed that the greatest loss, until the delivery is higher than 700 boiler horse-power, is due to heat leakage, which shows how very important it is to have the line well insulated.

WILLIAM J. CROWELL, JR.

Lebanon, Penn.

"Effect of One or Two Throttles on a Duplex Steam Pump"

In reply to Frank J. Wood's letter on page 475 of the July number, I should say that he could better control the pump with two extra throttle valves than with one.

The reason is that when a pump is newly packed there may be more friction on one side than on the other; also, when packing is set up the pump is liable to short stroke on one side. Then too, the lubricant may flow more freely on one side than on the other, and this will cause a short stroke. If there is lack of oil, by piping the lubricator to each branch of the throttle pipe, the oil can be regulated to suit conditions. When the pump gets into this condition, the throttle should be closed on the long or full-stroke side, until the pump gets to working "square."

If oil causes the trouble a short run will remedy matters, but if it is caused by packing friction, tighten or slacken the parts, until the pump gets into proper working condition. Cushion valves will help out considerably. By having three throttles an even and full stroke can be maintained, thereby saving steam and pumping more water.

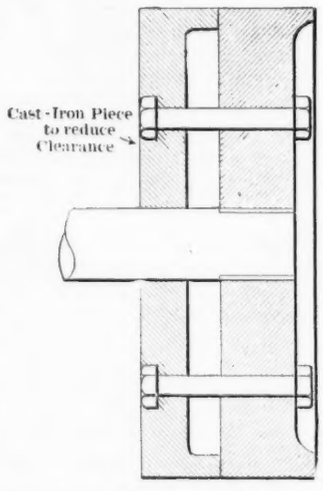
HELOS.

Sterling, Ill.

Overhauling a Second-hand Engine

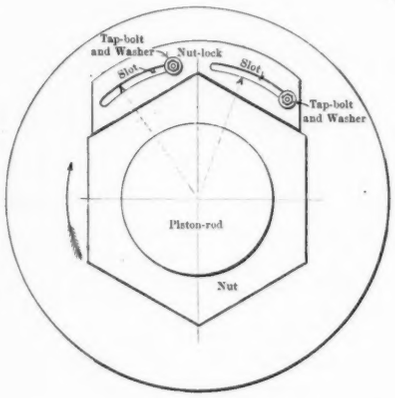
A short time ago my employers decided to install an electric plant, and they began by purchasing second-hand machinery. After a good deal of "skirmishing" they found a second-hand engine and generator "cheap." The generator was a Crocker-Wheeler 11.5-kilowatt direct-current machine in very good condition; the engine was a 9x9 vertical slide-valve type, made by a well-known firm. Everything was hurried to get the unit going, and it "went" with a vengeance! It was a veritable trip-hammer, and heat—well, I guess. We shut off the steam and proceeded to make an investigation.

Taking off the crank-pin brasses, it was found that they were brass to brass and nipped at the edges, and the oil grooves had become obliterated. The brasses had scraped the oil off the pin likewise. The crank-pin itself was found to be badly "out of round," so we placed it in a lathe and turned it to fair condition. The brasses were "eased" at the edges, and new oil grooves were cut in each box by laying a strip of tin or brass, bent to the curvature of the box, inside of it, and using this strip as a guide for marking off; a bent chisel, such as is used for grooving, did the rest. In fitting the boxes a small quantity of red lead was used, to indicate where the box bore the hardest.



HOW THE CLEARANCE WAS REDUCED

The brasses of the engine had been adjusted by means of a steel set-screw, with a lock-nut, at the bottom of the connecting-rod. The result was that at every adjustment, after running a short time, the set-screw was driven up into the bottom of the box and the latter became loose. In addition, the box was pounded out of shape, thus causing heating. The connecting-rod was removed and the outside of the bottom end planed off. The rod was made with solid ends; that is, it had no loose strap, gib and key. The engine was of the side-crank type, the boxes being held on the pin by a thick flange secured by a cap-screw tapped into the end of the pin. A taper key was made and a hole drilled into the jaw of the connecting-rod, a stud-bolt with a lock-nut being inserted to hold the key in place. This gave a good, solid bearing for the boxes. The crosshead was fixed in the same manner. Upon inspecting the cylinder and valves the clearance was found to be 3/8 inch when the engine was on the top center and 2½ inches when on the bottom center.



METHOD OF PREVENTING NUT FROM SLACKING

The piston, which was of the solid type with snap-rings, was removed, and with a hollow wood pattern a casting was made and turned to the same diameter as the piston. The piston was faced up in a lathe, as were the edges of the casting. A hole was bored in the center so as to enable it to be slipped over the piston-rod, making a rather loose driving fit. This construction is shown in the sketch herewith. Six holes were bored through the piston and corresponding holes in the casting, and the bolts put in with a driving fit. After screwing up the nuts, the ends of the bolts were slightly headed, to prevent the possibility of working loose. This provides a clearance of ½ inch, instead of 2½ inches, as formerly. The valve was planed and scraped to a bearing, and in resetting the valve a little more lead was placed on the bottom than at the top, on account of the weight added to the piston. Upon starting up it was found that we had a very different running engine, and it certainly was not so extravagant in the use of fuel.

C. H. T.

Bridgeport, Conn.

"Loose Nuts and Narrow Escapes"

The loose piston-rod nut trouble referred to in a letter from Mr. Cederblom, on page 388 of the June number, can be avoided frequently by adopting the scheme shown in the accompanying sketch. The nut-lock or keeper, or whatever else it may be termed, may be a brass casting from a pattern, if a sufficient number of them are to be required. If only one engine is to be equipped, then sheet brass or plate iron can be used to advantage, especially when cost has to be considered.

By slacking the tap-bolts which clamp the keeper to the crosshead, the piston-rod nut may be tightened to a new position without removing the keeper from its place. As will be seen, the slots will permit a certain amount of nut movement before it will be necessary to shift the position of the keeper.

The device is not original with me, but I have seen it used upon a number of engines, with the result that the nuts never became slack. Where there is sufficient room on the crosshead, I think it would pay to put on a keeper and save worry.

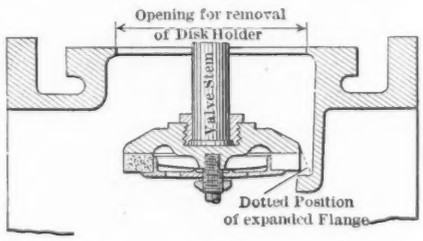
CHAS. J. MASON.

Scranton, Penn.

Trouble with Composition Disks

Three years ago the composition disks on two of my four-inch stop-valves became worn out. In fitting new composition disks I had them put in the lathe and turned to fit the cavity in the disk-holder exactly. A few days ago the packing between the bonnet and body of one of these valves blew out, and when I removed the nuts and attempted to lift off the bonnet, to my surprise I found that the disk-holder would not come up through the opening.

By the aid of a short bar, after much trouble I succeeded in deforming the holder until I was able to work it up edgewise through the opening. The composition had swollen and consequently expanded the outer rim of the holder, until the diameter of it became greater than that of the opening.



TROUBLE WITH COMPOSITION DISKS

I have guarded against a recurrence of the trouble by making the new disk 3/16 inch smaller in diameter than the cavity into which it fits, thus allowing for expansion. The accompanying sketch will help to make the trouble plain.

R. MANLY ORR.

Brantford, Ont.

Mr. Brand's Dynamo Sparking and the Care of Brushes and Commutators

H. B. Brand did not state, in his letter on page 395 of the June number, whether his dynamo has wire-gauze or carbon brushes, nor whether sparking occurs at certain segments only, or all around the commutator; which information would have helped in diagnosing his trouble.

It is most important that the tips of the brushes should be diametrically opposite, and if not already done, two segments at opposite sides and exactly half the circumference of the commutator apart should be distinctly marked.

All brushes should be taken out and trimmed carefully. The best way to do this is to make two pieces of hard wood, as indicated by the sketch herewith, and cut them off at the ends to form the same angle that the brushes make with the commutator. The brushes, if of gauze, are first squeezed up in the vise until of their original thickness (they are sure to have spread with running), the tips are then cut square across with shears or a sharp chisel, and the brushes are clamped in the vise, one at a time, between the wood blocks and filed to fit.

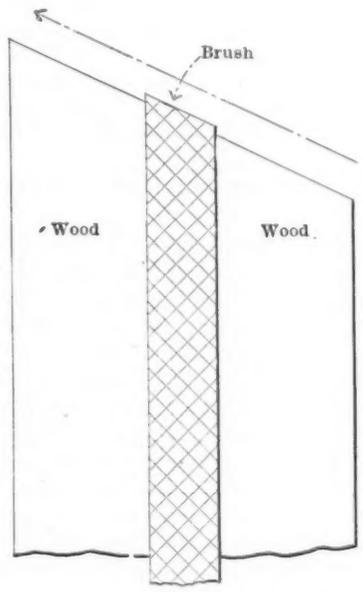
Always file straight up toward the tip, as shown by the arrow in the sketch, and then with the shears nip off any loose pieces of wire which may have come out. One brush should then be fixed in each row, taking care that both project an equal amount from the holders. Turn over the machine until the marked segments of the commutator come under the edges of the brushes, and set the brushes so that both just toe the leading edges of the marked segments. If they require adjusting to the marks, slide one *into* its holder and slide the other *out* a little; then set all the other brushes of each group in line with the first ones.

With carbon brushes, once the holders are set, most types of brush-gear will not require readjustment as the brushes wear down, but the spacing is equally important. To bed down a carbon brush, file it up as nearly as possible to fit the curvature of the commutator, clamp it in the holder and see-saw a long piece of emery cloth or fine glass paper backward and forward underneath the brush, lifting the brush up on the backward stroke; that is, when pulling the cloth in the opposite direction to that of the rotation of the machine; continue this until every part of the brush will make good contact with the segments. Then wipe the face of the brush with a rag moistened with paraffin oil, and clean off all dust.

Whenever possible, the brushes should be "staggered," that is, one should be fixed near the bearing end of the brush spindle, and the opposite set near the armature, so that their paths of contact with the commutator will overlap each other and promote equal, level wear.

Whenever gauze brushes show signs of spreading out thick at the ends, they should be trimmed, as by being thick they short-circuit more segments than they should and cause sparking and heating of the armature windings.

One very important point, upon which too much stress cannot be laid, is to keep the commutator clean, and the writer has found that the best thing for this purpose (with either carbon or wire-gauze brushes) it paraffin oil, which should be used sparingly on a clean rag, holding in front of this, in the direction of rotation, a pad of dry rag to insure that the paraffin and



HOW TO TRIM A WIRE-GAUZE BRUSH

dirt are all wiped off and not carried under the brushes.

If the brushes score the commutator at all, giving it the appearance of having been filed, rub on a little paraffin wax in the case of carbon brushes, or with gauze brushes a mixture made as follows: Take equal parts of pure castor oil and spirits of turpentine and add liquid ammonia, drop by drop, shaking at each addition, until the mixture appears like milk. This should be kept in a glass-stoppered bottle, and shaken before use, applying it with a piece of rag. Never on any account use ordinary lubricating oil, and only use the above lubricant sparingly, enough to just moisten the commutator and stop the scoring action. If any great excess is appiled and it gets into the brushes, wash them with benzolene, or petrol.

It is a good plan to make a rule of wiping the commutator every hour at least with a dry rag, applying the lubricant at any time it appears necessary, which a little experience will soon enable one to judge. Carbon brushes should never be allowed to "screech," but the commutator should be cleaned with paraffin oil, lubricated with wax, and if this does not stop the noise, the offending brush (provided there are at least two on one spindle) should be lifted up and wiped, as most of this trouble is caused by particles of grit.

Some people object to touching a running machine, but if everything is to be kept O. K. during long runs, it is an absolute necessity, and with a rubber mat to stand on there is very little risk to a careful man.

Under the above-mentioned treatment a commutator should take on a dark gloss which is a protection against wear, and should never need cleaning with emery cloth or glass paper. An occasional wash with paraffn oil, when the machine is standing, is also advisable, as one can rub harder and get the dirt off better.

So far it has been assumed that there are no faults in the machine. Mr. Brand states that it is clear of ground, but as previously pointed out, he does not say whether the sparking is continuous all around, or only at certain segments, nor whether any flats are formed. Sparking only at certain segments may be caused by a broken connection between the armature winding and the segment, or by vibration of the machine.

The writer remembers a case of two bipolar dynamos direct-coupled to a high-speed engine (for use as balancers on a 3-wire system), which developed very bad flats extending over four or more segments at opposite sides of the commutators, and the flats on both machines coincided exactly. The machines had been bolted to a temporary wooden bed, and all trouble vanished after the commutators had been trued up, and the set fixed on a proper concrete bed, the sparking having been caused by vibration. The brushes in this case were of carbon.

Slack bearings, armatures out of balance, or driving belts with stiff joints, may also cause destructive sparking and flats. Also, if all segments are not made of the same quality of material, the softer ones will wear away sooner, and as soon as they get appreciably lower than the rest, sparking will commence.

A flat, needless to say, should always be attacked in good time, as the longer it is permitted to run, the deeper it will be burnt, and filing down the segments on each side is only a temporary expedient; the proper shape for a commutator is circular and it should run true.

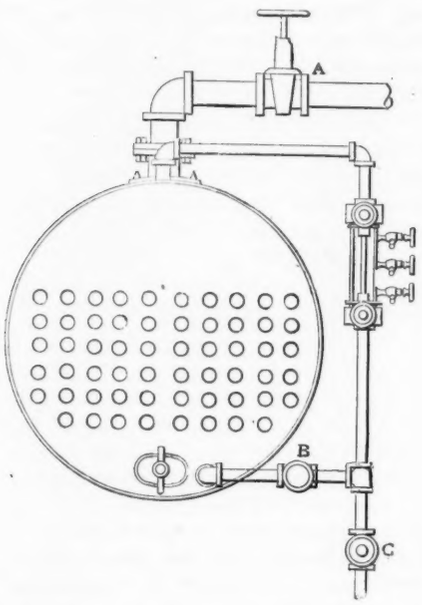
There are so many points in the design of a machine, which affect its behavior, that it would take a lot more space to go into them all, but Mr. Brand is advised to try the above expedients first.

A. W. Empson.

London, England.

Information Wanted Concerning Blow-off Valves

While doing some work around the engine room one Sunday the chief told me to put a new blow-down valve on the water column on one of a battery of five horizontal tubular boilers. Two of the



LOCATION OF MR. SHEEHAN'S BLOW-OFF VALVE

boilers were making steam at the time and while the fires under the others had been drawn the night before, they were connected to the steam main and were under the same pressure as the other two. The new valve was needed on one of the three under which there was no fire. I shut the valve on the water connection, shown at *B* in the accompanying sketch, and then that on the steam connection at *A;* then I pulled out the old valve at *C* and put in a new one. The chief told me to climb up and open the steam valve *A* and at the same time he started to open the water valve *B*. The new valve had been left open to prevent the gage glass from breaking. All went well until I started the steam valve, then I thought my time had come. Everything around me started to jump; I was scared all right, but I shut the steam valve and the racket stopped. The chief then shut the blow-down valve and I opened the steam valve once more. This time everything acted all right. I asked the chief what the matter was, and he said, "O, nothing."

I thought no more about the occurrence until the other day when I went to be examined for a first-class license. One of the questions the examiner asked was: "If you were in charge of a large plant and ordered one of your firemen to cut out a boiler; and if he pulled the fire, but did not cut her out, but went off duty and did not tell the oncoming man she was not cut out; and the steam condensed until the boiler was full of water, and you happened to notice it, what would you do? Would you open the blow-off valve?" I said, "Sure;" and this is what he told me: "You are here looking for a first-class license and yet you have just told me how to blow up a boiler; for that is what caused the explosion at Brockton, Mass." I got no license.

Afterward I asked three or four first-class engineers about this question. They said the examiner did not know what he was talking about, as opening the blow-off under these conditions would not hurt anything. But when I compare my experience in that line with his question, I think there must be something in it. When I opened that steam valve it certainly sounded as if there was something in it—and I thought it was coming out. I would like to hear from some of your readers on this matter.

THOMAS SHEEHAN.

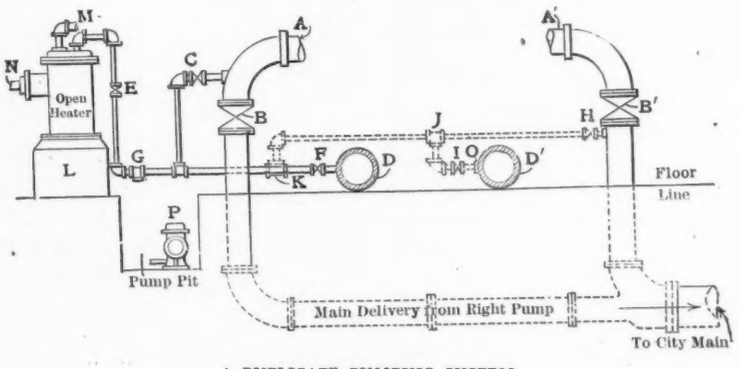
Adams, Mass.

A Duplicate Pumping System

A friend has charge of a water-works pumping station and the other day I dropped in to "visit" with him. While I was looking around the plant the engineer repeatedly told me that one of the principal features of the outfit was that everything was in duplicate and that if one pump gave out he could easily run the other, etc. While he was talking one of the pumps began to knock slightly on one end of one side and investigation showed that the trouble was due to two broken valves in the inboard suction chamber of the left-hand pump.

In the accompanying sketch at *A* and *A'* are shown the delivery pipes of the left- and right-hand pumps. It took but a short time to start the right-hand pump, but when the engineer cut out the left-hand pump entirely, including the supply and delivery valves, the situation became serious, for, as will be seen, by cutting out the delivery valve *B* and closing the valve on the supply pipe *D*, as the water came under a pressure of three pounds, the pipe leading from the valve *F* would be dry and also the pipe leading from the valve *C*. There was but one course to pursue and that was to leave the by-pass on the valve *B* open, so as to supply the pump through the valve *C*, until some arrangement could be made to get water from the delivery of the right-hand pump. The engineer hurriedly decided to put a saddle joint on the right-hand delivery as shown, near the valve *H;* a flange joint was fitted to the right-hand supply pipe at *O*, as shown by the dotted lines. This latter fitting, of course, was not put on until the right-hand pump was cut out entirely, but when the saddle joint was fitted near the valve *H*, this line was provided with a plugged tee, as shown by the dotted lines at *J*. Putting the plug in the tee allowed its immediate use, so that the left-hand pump could be cut out entirely.

The two auxiliaries—the independent air pumps—are not shown in the sketch; but their exhaust piping, with that of the boiler feed-pump *P*, all connect under a back-pressure valve on the pipe *N*, on the open heater. The connection at *M* on the top of the heater is intended to represent the connection from the air-pump discharge pipes, delivering the condensation to the heater to be fed to the boilers again. The valve *E* is on a reserve line that supplies the heater when the demand is greater than the supply of water to the heater from the air pumps. The connection at the tee shown at *G* is also a reserve supply to the boiler-feed pump, when the heater is being cleaned or undergoing repairs. Considerable stress was brought to bear with the management and a duplicate 6x4x6-inch pump was installed in the pump-pit alongside the other one. The rearrangement was put in operation while I was at the plant, barring the valve *I* and the connection at *O*, on the supply pipe *D'*, and it worked admirably. It proved also that while there was water all around him, the engineer could not get it for his boilers, the *most* essential feature, and it also showed that the "duplicity" of his plant was "weighed and found wanting."



A DUPLICATE PUMPING SYSTEM

Depew, N. Y. C. W. DUNLAP.

"Etiquette in the Engine Room"

Touching the query in July POWER, page 479, by "H. H. H.," I would say that the etiquette of the engine room, as everywhere else, requires everyone to perform the duties for which he is employed and to leave those which have been delegated to others to the persons who have been employed to perform them. When I was working as an assistant, I made it a practice not to hang around the chief and watch his work, unless invited to do so. Of course if he is a good man, and disposed to show courtesy to his assistants, he will extend privileges to them, the extent and nature of which will be determined by his disposition and judgment.

All men dislike a "butter-in," and all agree that it is bad taste, to say the least, for an assistant to undertake to perform duties which are supposed to belong to his chief, unless he is invited or has permission to do so. So far as I am concerned personally, I never had any objection to giving an assistant information that would add to his value to himself or his employer, but for him to presume to perform my duties, without consulting me, I certainly would consider the exhibition of lack of good sense, or a superabundance of "gall."

In a case of this kind it is a good plan for the inquirer to put himself in his chief's place. He will have little trouble answering the question for himself. A good chief will extend any reasonable courtesy to a good assistant, but it is in just as bad taste to usurp the privileges or duties of another, especially in a case of this kind, where it may cause complications to arise, as it would be to take anything else that belongs to another.

B. CAREFUL.

Charleston, Mo.

"Feed and Blow-off Pipes"

J. O. Benefiel's scheme for blow-off, on page 480 of the July number, is a very good one for protection of the pipe. Of course, the bricks should not touch the pipe. I also fully agree with him about feeding through the blow-off. I have handled and know of very many boilers fed in this manner and have yet to hear of any trouble or expense for repairs.

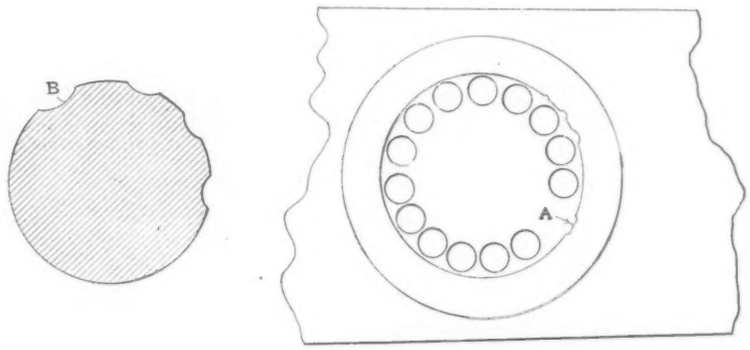
As to his wanting to be shown why feed-water should enter at the coolest part of the boiler, if he would stop to think of the enormous strain set up by expansion and contraction the reason would be plain. Suppose the feed to be at 200 degrees Fahrenheit, and consider the temperature of the water boiling under pressure of 100 or more pounds. If this feed-water enters over the fires, where most heat is transmitted, it will set up a greater strain than if entering near the rear end, where it is much cooler.

WILLIAM CHADDICK.

Chicago, Ill.

Why Automatic Governors Fail to Work

The illustration shows a governor pivot and the condition of the roller bearing These rollers had become imbedded in the pivot pin, as at *B*. The lever worked by jerks and was nicked as shown at *A*. The engine is now running with a bushing made of aluminum and the governor is doing O. K. The working parts have less friction than they had with roller bearings. Roller bearings in generators are generally failures in my opinion, although they look well in theory.



SHOWING CONDITION OF GOVERNOR PIVOT AND ROLLER BEARING

C. R. MCGAHEY.

Atlanta, Ga.

How to Indicate a Marsh Pump

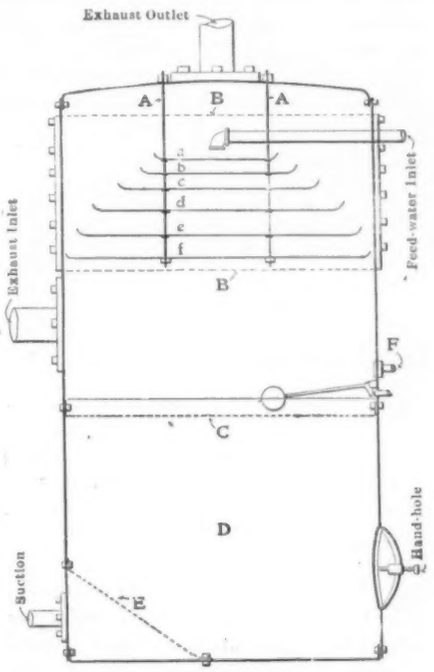
I have my own way of doing it, but I would like to hear from other POWER readers how to indicate a Marsh pump.

WILLIAM CHADDICK.

Chicago, Ill.

"How Can He Improve His Heater?"

On page 396 of the June number D. A. Steiner asked how to get oil out of the steam; and in the July number W. F. Burrow asked a somewhat similar question. The answer is: Filter through excelsior, and plenty of it.



MR. BARBER'S HEATER

The accompanying outline sketch shows how I have altered a number of open heaters. I take out all the inside parts and throw away any oil extractor which may be attached to the heater. In the sketch, *a*, *b*, *c*, *d*, *e* and *f* represent trays or shelves, with their edges turned up, *A A* being rods to hold them. Directly over them is the feed-water pipe. The dotted lines *B B* show where part of one side has been altered into a door to take out the trays for cleaning purposes.

The float operates a valve to maintain the water level at a point below the exhaust inlet, and there is also an overflow, *F*, which is open all the time. At *C* is a permanent perforated screen. The chamber *D* should be filled with excelsior the screen *C* keeping it from entering the exhaust chamber. A smaller screen *E* keeps the excelsior from getting into the pump suction pipe. This pipe ought always to be near the bottom of the heater.

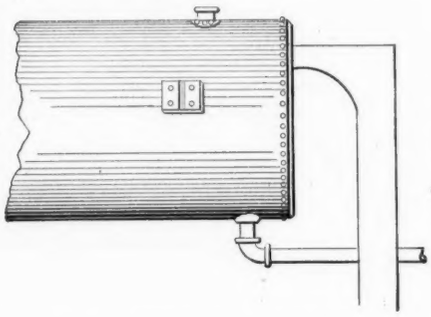
I have taken in hand boilers which were in pretty bad shape on account of the oil that got into them, and after cleaning them with potash or lye in hot water, rinsing thoroughly, and altering the heater so as to filter the feed-water through excelsior, had no further trouble.

GUY M. BARBER.

Falconer, N. Y.

"A 100-Horse-power Steam Plant"

Much valuable help may be found in the descriptions of the 100-horse-power plants in the July number. Mr. Hobart's plant as a whole looks to be thoroughly practical and up to date, but neither he nor either of the other authors has anything to say about smoke prevention, which in most localities is far from the least important feature of even the smaller plants.



IDEA FOR COMBUSTION-CHAMBER ROOF

I like the setting of Mr. Hobart's boiler; there is plenty of room under the shell and it ought to prove a good steamer; but my experience with T-irons in the roof of the combustion chamber has been that they sag too easily. I think the construction shown in the accompanying sketch is better.

The 66-inch boiler insures ample steam space, but without dome or dry-pipe would not some kind of baffle-plate directly under the nozzle be advisable? I have seen on banked boilers safety valves which, when lifting, would throw out a solid stream of water, mud and scale, that must have come from the very bottom of the boilers. We cannot always depend on a steady pull from the engine, and a sudden rush of steam will generally lift some water. Mr. Hobart runs his drip-pipes directly into the sewer, a practice that may be O. K. in some localities, but would not do in this city, where some kind of trap must be provided to insure that only water, and no steam, goes to the sewer.

He is all right in regard to where the feed-water should enter. As to the real merit of this practice, I think it is about as unsettled as the question of superheated steam. If the practice has any good features at all, I think they are more than offset by the trouble of finding other means for protecting the blow-off pipe. I agree with what J. O. Benefiel says on this subject, on page 480. No engineer who has any means at all of heating his feed-water will feed cold water into his boilers, and as long as the feed is hot it makes little difference where it enters the boiler.

Mr. Hobart does not show any protection whatever for his blow-off pipe. With a manhole under the flues, in the front head, the hand-hole in the rear head seems superfluous and, exposed as it is to the flame, it is a source of more or less trouble. The figures given by Mr. McGahey on the same subject appear too low for average conditions, and as to his engineer's salary—working sixteen hours and a half at times, doing his own firing, all for the munificent sum of $65 per month—this item might profitably have been omitted.

R. CEDERBLOM.

Chicago, Ill.

I heartily agree with Mr. Hobart in what he says about the unnecessary piping in some plants. His plans for a 100-horse-power plant seem simple, yet cover every point, and I am especially pleased that he favors the Corliss engine. Instead of allowing 24 inches between the grate and boiler, 30 inches would be preferable, I think, at least with Illinois coal, in order to permit better combustion of the gases before they come in contact with the cooler boiler shell.

I also prefer the feed-water to enter through the blow-off, in order to maintain a circulation in this pipe and so prevent the danger of clogging and burning.

There is no smoke-consuming device provided for in any of the plans, and this is a very important point at present in large cities. I think suggestions of ways and means in this direction applicable to old plants would be interesting and profitable. Personally I like the dutch oven, where there is room for it outside the boiler, but on no account would I have it built, as in some plants, covering one-third of the shell, thereby cutting this much heating surface off from the direct and most effective action of the fire.

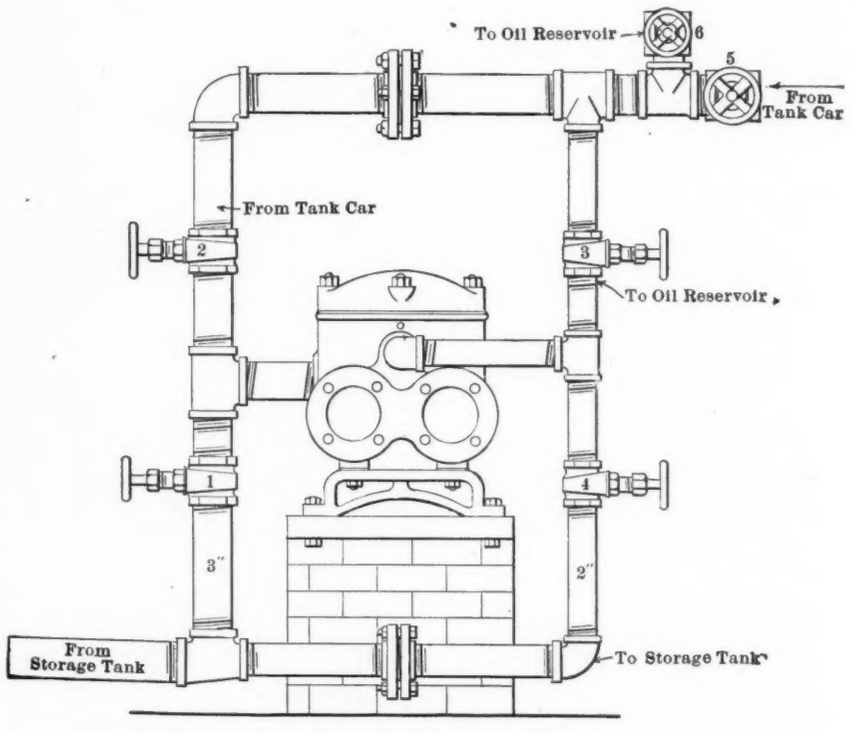
WILLIAM CHADDICK.

Chicago, Ill.

A Successful Piping Job

A pump in our boiler-room is located half way between the track for an oil-tank car and a 9000-gallon storage tank, the latter being 200 feet south, and the car track 200 feet north of the pump. It was decided to erect a small tank near the point where the car stands to be emptied, and pipe oil from this small tank to the point of delivery. A tee and a valve were put in the line running from the tank car to the pump, and a branch with a valve in it was run to the small tank. See the accompanying sketch. By closing valves *A*, *B* and *C*, and opening valves *D*, *E* and *F*, oil is drawn out of the storage tank and discharged into the small tank, or oil reservoir; then by reversing this operation, oil is pumped from the tank car and forced into the storage tank.

We are so elated at the successful issue of this piping job that we intend to make this pump also do the work of a 10x6x10-inch pump that is very much underloaded, by substituting a cross in place of the tee in the suction and discharge outlets of the pump, and running branches fitted with valves and flange unions to the suction and discharge pipes of the larger pump; thus more economically pumping the water needed in a certain line of work.



A SUCCESSFUL PIPING JOB

P. J. KEATING.

Streator, Ill.

"How Would You Correct the Crank-end Diagram?"

In regard to the diagrams submitted by A. P. Aldrich, on page 395 of the June number, I cannot agree with J. Burns' suggestion, on page 475 of the July number. As the diagrams show good admission and compression on the head end, and as the late release on the crank end indicates late admission, high compression and good release, I think the eccentric-rod is too short and the rods between the wrist-plate and the bell-cranks of improper lengths. I fully agree with Mr. Burns as to moving the tripping cams to equalize cut-off.

L. T. STUART.

Bingham, Utah.

The trouble with A. P. Aldrich's engine is that steam is admitted late at the crank end, and the head end is doing most of the work. Set the valves a little at a time to open earlier, until the diagrams show a vertical admission line, and as nearly as possible the same area at each end.

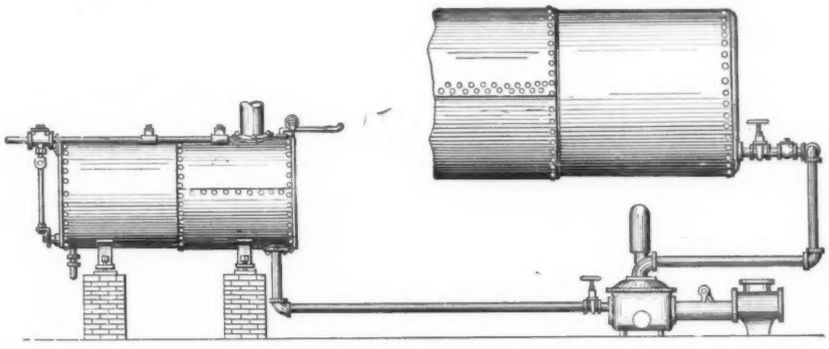
It will be found that as the crank-end diagram grows larger, so the head-end diagram will get smaller, due to earlier cut-off, and the engine will turn much more evenly.

A. W. EMPSON.

London, England.

Pumping Hot Water Is Different from Pumping Cold Water

Pumping hot water is quite different from pumping cold water, as the following will show. The sketch shows a Hoppes open heater in connection with a steam-actuated pump which was installed to raise the feed-water from the heater to the boiler, as shown. In doing so the pump would take the water all right, but would "hammer" so that it seemed as if the piping was about to come down. To remedy it, I almost closed the valve in the delivery pipe and in a few seconds the pump became quiet and has been running nicely ever since. The only thing needed was to put more pressure on one side of the pump. The water from the heater was at steaming point, and formed an elastic cushion on each side of the piston on the water end, which caused the pump to work by jerks. By almost closing the valves, allowing just passage enough for the water, this trouble was readily overcome. This pump had steam-operated valves, which had a tendency to make it worse, as the steam is admitted to the steam end almost instantaneously, causing a quick movement of the plunger, and the elastic fluid at the other end had the pump "crazy."



SHOWING PUMP AND HEATER CONNECTIONS

Hot water should always be above the suction on a pump and by graduating the inlet valves to the boiler there will be no trouble.

C. R. MCGAHEY.

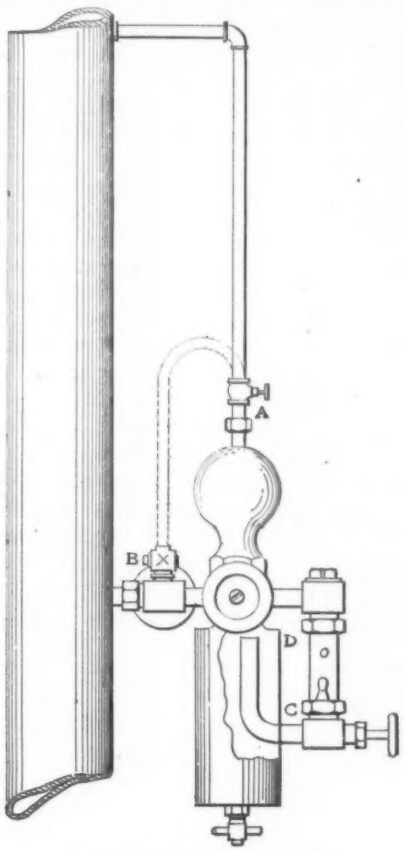
Atlanta, Ga.

"Why Would Not the Lubricator Work?"

On page 472 of the July number, Arthur R. Mutton relates the erratic performance of his single-connected lubricator. The writer, having had trouble from this source, succeeded in remedying it in the following manner. In the accompanying sketch the original connection is shown by the dotted lines. This was removed and a 3-foot vertical pipe was attached at *A*. Not having a plug of the required size to insert at *B*, a plug of larger diameter was screwed into a gas fitting, the male end of which was the right size, and this served the purpose so well that no more trouble was experienced.

A lubricator once burst and a crack extended from *C* to *D*. An assistant had refilled the lubricator after shutting down one of the engines, and as the lubricator was located close to the steam chest and the temperature of the room was very high, sufficient heat was absorbed by the oil to cause trouble from expansion. It was decided that if the condenser valve *A* had been left open, the expansion of the oil could have been relieved by means of the condensing pipe.

I am not in favor of the single-connection lubricator, especially in very warm places, or where short connections are used. They frequently become inoperative owing to the impaired condensing head of water necessary for perfect operation.



MR. SHERIDAN'S LUBRICATOR

JAMES G. SHERIDAN.

Brooklyn, N. Y.

"Why More Fuel to Sustain Lighter Load?"

On page 470 of the July number August Weis presents the above problem, and the only explanation which occurs to me is that the engine works more economically and exhausts the steam hotter at full load; while at half load she is really taking more steam in proportion to the load, and as the greatest part of the radiating heat is obtained from the latent and not the sensible temperature of the steam, therefore to make up the deficiency in the volume of exhaust a greater amount of live steam must be used than would be required by the engine at full load. In the latter case we would have four or five times the volume of steam at the end of the stroke for heating, that is, four or five expansions in the cylinder; while at light load the steam might expand eight or nine times, according to the point of cut-off, and be just so much cooler when exhausted.

WILLIAM CHADDICK.

Chicago, Ill.

Time-saving Suggestion for the Noon Hour

A firm with which the writer was once associated had just installed a power plant with electric drives throughout the shops. The power equipment consisted of two 800-kilowatt turbo-generators, two 25-kilowatt turbo-exciter sets and a 150-kilowatt synchronous motor generator set for supplying direct current to the elevators and a few other direct-current motors. The circulating water and hot-well pumps were driven by induction motors.

The customary method of starting up one of the turbos, when the plant was first installed, was to start one of the exciter sets and, using the direct-current side of the motor generator set as the motor, take off alternating current from the other side to drive the hot-well and circulating-pump motors. The turbo was then started, excited and brought up to speed, and the voltage regulated. The pump motors were then thrown on to the main bus-bars by a double-throw switch; the motor generator set was synchronized and thrown on the bus-bars; the direct-current side disconnected from the exciter set and, acting as a generator, thrown on to the service bars, and finally the alternating-current service switches were thrown in.

The time consumed by this method of starting was about 25 minutes, and as the direct current was required by 12.55 p.m., the engineer had a decidedly busy noon hour. He racked his brain to make the work easier, with the result that with a little outside advice he cut down the starting time to ten minutes or less. This was accomplished in the following manner:

A 1-inch by-pass from the fire-service mains, which were always under 80 pounds pressure, was tapped into the circulating-water pipes and opened up just before starting, thus providing sufficient circulation of the cooling water until the regular pumps could be operated. The exciter set was started as before, then the turbo-generator, the synchronous motor and the pump motors were all thrown directly upon the main bus-bars, the big machine was excited and then started up, dragging the others into step with it. The induction motors never gave trouble and if the synchronous motor failed to start it was boosted by exciting it for an instant, when it would immediately pick up.

When up to speed the turbo-generator was brought to normal voltage, the synchronous motor excited, its direct-current side adjusted and thrown upon the service lines. The fire-service by-pass was shut off and everything was ready to pick up the load in short order.

Synchronous motors at their best are machines a long way from perfect to handle, but so satisfactory has this scheme proved that it has been in operation in this particular plant ever since, to the immense gratification of the engineer and the power superintendent, who take great pride in the ease and rapidity with which one man is able to start up.

WILLIAM K. JERVIS.

Worcester, Mass.

Repairing a Gas Engine

A single-cylinder gas engine had passed through several wrecks, in one of which the crank-shaft became slightly bent. This was not straightened because the fly-wheel keys had been driven in with 25-pound sledge hammers and all the efforts to back the keys out only resulted in spreading the soft steel of which the keys were made. As there were four keys each 14 inches long, it would have been too much of a job to drill them out, so it was decided to try the shaft as it was. It was found that the fly-wheels were not enough out of true to prevent running; but the crank-pin, being slightly twisted, proved a constant source of trouble from heating, in spite of many dressings. As a partial relief the

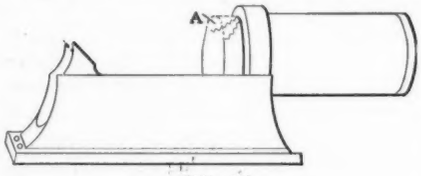


FIG. 1

crank-pin boxes were left very loose, with the natural result that a nerve-racking pounding was kept up.

This pounding was at last noticed by the manager, who forthwith asked the engineer if he were going to do anything for it. The engineer explained, but the manager was not satisfied. "I'll try it myself," he declared. First he calipered the crank-pin, then he dressed off the brasses until they cleared on each side by about a quarter of an inch. This space he filled with rubber packing and drew the brasses to a tight fit on the pin by means of the adjustment bolts.

The engine was started up and the most critical observer had to admit that it ran more smoothly, and without heating, than for a long time. Then the engine was left by itself, and this seemed to have been what it was waiting for. Without warning, a savage knocking came from it, followed by a heavy crash. Hurrying to the engine room the men found what looked like a hopeless wreck. A large three-cornered piece had been split from the top of the crank-end of the cylinder, the brasses were found twenty feet apart, and the piston and connecting-rod had gone through the roof. A careful examination showed that the jam-nuts that held the brasses in place had broken off. Very likely the soft rubber liners had "given" enough to allow the jam-nuts to become loose, and as the lower nut worked off the end of its bolt, it caught on the engine bed, breaking the bolt; and, of course, the other nut was not long in following suit.

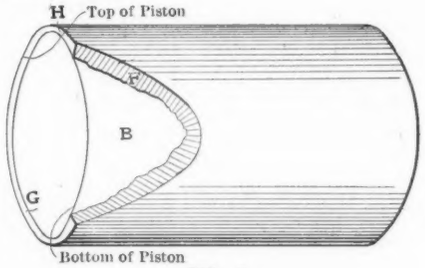


FIG. 2

New bolts were made, some bad dents dressed off the crank-shaft and the three-cornered hole in the end of the cylinder rounded into a more regular form, with its under edge beveled off a little (see *A*, Fig. 1). Then attention was given to the repair of the piston. Besides several nicks and roughened places, a large roughly-triangular piece was broken out of the under side in front, very similar to the piece broken from the top of the cylinder. Two of the packing rings were broken, but several extra rings were on hand, so that did not amount to anything. The broken place, *B*, Figs. 2 and 3, was first trimmed fairly smooth, then 1x2-inch iron rings, *C* and *D*, Fig. 3, were riveted inside the piston, care being used to make the distance *E* great enough to prevent the connecting-rod from striking against the ring. Then the outer edge of the broken place, *F*, Fig. 2, was beveled, and the piston was shoved back into the cylinder until the end *G*, Figs. 2 and 3, extended back past the end of the cylinder about an inch, and it was blocked up a little with a tin clipping, to allow for a worn place found there. A piece of tin a trifle larger than the broken place was then placed inside the inserted rings and weighted there, with its wedges well plastered with clay. The outer end or

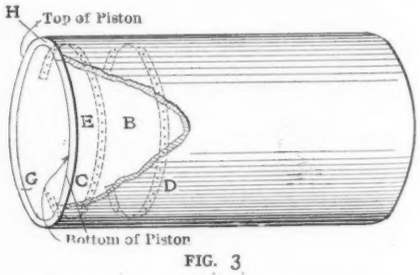


FIG. 3

edge was also solidly filled with clay, leaving a pouring basin at *H*, Figs. 2 and 3. Melted babbitt was poured in and after it had thoroughly cooled the piston was drawn out and the babbitt carefully trimmed and scraped. After replacing the removed parts, the repair was finished.

In about a week a new piston was

placed in the engine, although the repair showed no signs of giving way.

ROYAL WOLFE.

Lancaster, O.

"Use Hydraulic Check Valves"

In MAY POWER the question was asked how to keep a hydraulic-gage pointer from vibrating. As I had had considerable experience along this line I gave as the result the advice to use two ¼-inch globe valves in a long gage pipe. On page 559 of the August number "Lled" suggests that length of pipe has nothing to do with it, "that it is all in the cock."

"Lled" is talking about 100 pounds steam pressure in the main steam pipe, while the rest of us were talking about the water pipe from a hydraulic pump, with from 1000 to 2000 pounds pressure. The cases are not exactly parallel.

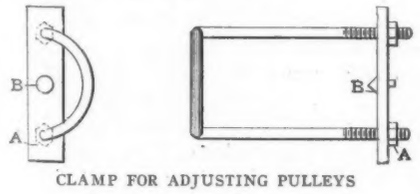
W. E. CRANE.

Boston, Mass.

Correcting Pulley Alinement—Loosening "Stuck" Pulleys

When a pulley slips out of line and becomes fast in the wrong position, it is often easier to move the shaft endwise, to get the pulley into place, than to move the pulley, although I have never seen a pulley that was stuck, or was loose on a set-screw ridge, that I could not move.

If the pulley can be revolved, but cannot be moved sidewise, I use a home-made clamp to adjust it with. The yoke of the clamp is made of ¾-inch round iron, bent as shown in the sketch. This is set around the hub of the pulley, the ends of the yoke extending beyond the end of the shaft; then the base is put on and held in place by the nuts *A*. The pointed piece *B* is made of hardened steel and set into a hole in the base strip, being so located that the apex of the pointed part will set into the hollow made by the lathe fixture in the end of the shaft. By tightening up on the nuts *A* and turning the pulley slowly at the same time, the pulley will true itself.



CLAMP FOR ADJUSTING PULLEYS

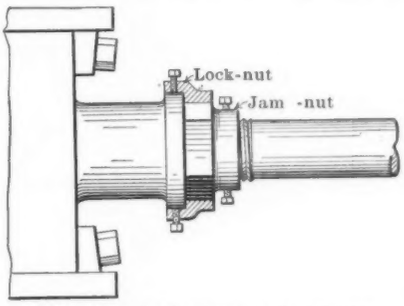
Sometimes the pulley is stuck so it is kept from revolving, in which case the remedy might be as follows: A loose pulley or collar may be located at the side of the stuck pulley and oil placed between; then while the shaft is revolved slowly, pressure is applied to the loose pulley with a crowbar, forcing the troublesome pulley from the tight point, the idea being to slide the pulley over by side pressure applied at the hub.

CHARLES HAEUSSER.

Albany, N. Y.

Troubles with Loose Nuts

Regarding recent letters treating of loose nuts at the crosshead end of a piston-rod, and loose holding nuts at



HOW THE LOCK-NUT WAS APPLIED

the piston-head end, reminds me of trouble I had with mine, and how I finally stopped the jam-nut from getting loose.

I had a lock made of cast steel, as shown in the sketch herewith. It has been in use more than nine months, running 143 hours per week, and has never lost its grip. The lock also preserves the length of the rod, as it is impossible for the rod to turn in the crosshead, even if the jam-nut were loose. This lock was made to apply to an engine in commission, but if I were having one built I would prefer to have the jam-nut and the lock in one piece; for when the lock is a separate piece care must be exercised to have any slack in the hexagonal opening taken up—in the "screwing-in" direction—against the corners of the jam-nut.

I have had but one experience with the nut at the piston head becoming loose. This was on a 16-inch circulating pump and the lost motion caused the rod to pull into it before it was discovered.

Alton, Ill. E. N. G.

Automatic Engine-stops

Some time ago a manufacturing corporation refused to pay $5000 for the death, by fly-wheel explosion, of an engineer, taking the ground that as the engineer saw the engine racing, he should not have gone near the throttle. Before the case came to trial the said corporation took the advice of counsel and paid the claim, being convinced that if the court were to rule that the engineer should not have gone near the throttle, engineers would be tempted to desert a duty they are hired to perform, namely, to be ready to close the throttle in case the governor fails to operate. Engines frequently race and engineers frequently close throttles in time to avoid mishaps.

We hear very little about racing engines, but runaways frequently get reported in the newspapers with photographs of the wrecked property. With steam at 100 pounds and over, increased speed of old engines as well as new, and the use of electric generators, the number of runaways has been tripled. Hence, the duty of the engineer has become more dangerous than in the old days of low steam pressure, slow speed and belt-driven machinery.

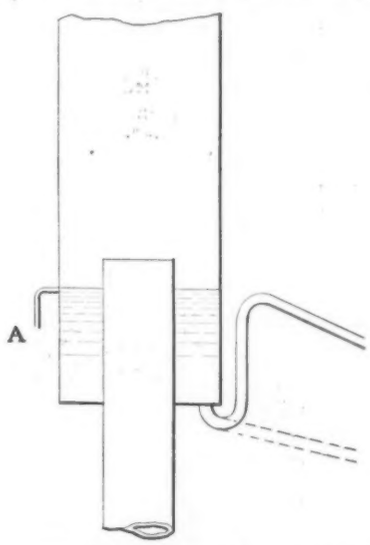
Why should a manufacturer take the chance of having his engineer killed at the throttle? Does it not behoove employers to equip their engines with automatic engine-stops and speed-limit systems, and leave no excuse for engineers to go near their engines in case of danger? It is a matter of dollars and cents, to be sure, but it is dollars and cents on the right side of the ledger, as anybody who has been through a fly-wheel explosion knows; and it costs no more for an engineer to run an engine with a good automatic engine-stop than without it.

SAFEGUARD.

Chicago, Ill.

Cleaning Oily Exhaust

On page 469 of the July number W. F. Burrow asks for suggestions in regard to separating oil from water of condensation. If a trap were made in the drip-



R. CEDERBLOM'S SUGGESTION FOR CLEANING OILY EXHAUST

pipe, as shown in the sketch herewith, and some kind of a skimmer with a small overflow, arranged as at *A*, I think he would be able to get rid of some of the oil before it reached the filter.

R. CEDERBLOM.

Chicago, Ill.

Feeding Steam Boilers

An engineer was going to leave his plant in charge of the fireman for an hour

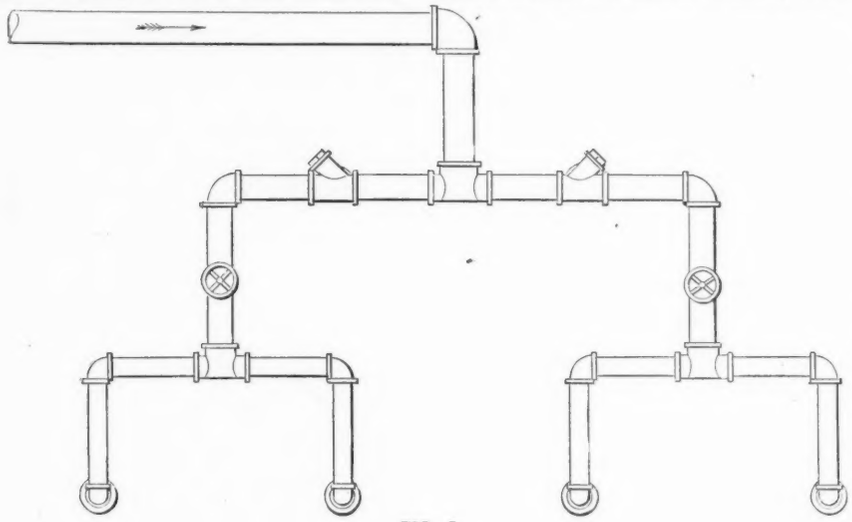


FIG. 1

or two, and as he was a comparatively new man the engineer gave him careful instructions concerning his work. He was told to keep the water level at the same hight in a pair of tubular boilers, and the engineer laid special emphasis on the statement that two boilers in a plant do not receive the same amount of water, even when fed by the same pump or injector, as the one under which the best fire is maintained takes the least water.

While I was surprised to hear this statement from him, it was not a new idea to me, as I have heard it before from others, but why should an engineer make such a statement?

Fig. 1 illustrates the feed pipes as they are arranged for a certain battery of two boilers. The feed water comes through the horizontal pipe shown, turns downward, divides at the reducing tee, and each half of it passes to a separate boiler under exactly the same conditions, as in this case it enters each boiler through two pipes as shown. There is absolutely no reason why more water should go to one boiler than the other, and it is perfectly safe to say that it is equally divided between them.

Why then does it fall faster in one gage glass than the other? Is there not a clue to the correct answer to this question in the statement made where the engineer says that there is less water in the boiler under which the best fire is found? His reasoning is defective concerning the cause of the difference, as it is strictly due to the fact that the best fire evaporates the most water in a given time.

No logical reason can be found in this case at least, and probably not in any other, for saying that the best fire causes more water to go to the other boiler. These boilers are connected by large steam pipes making it impossible for the pressure to be greater in one than the other.

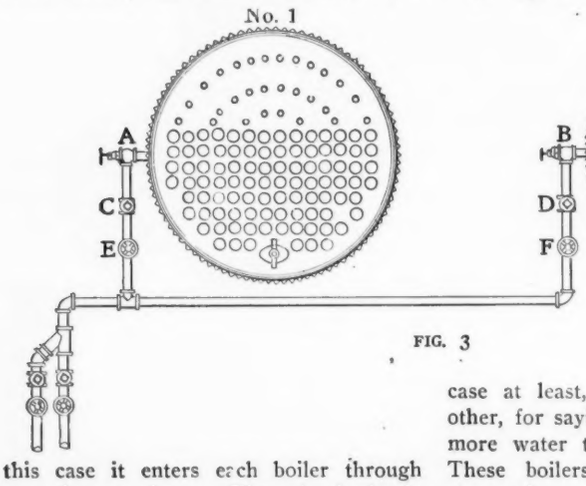


FIG. 3

Fig. 2 shows the feed pipes for two boilers as a certain engineer found them on taking charge of the plant. The first pipe on the left-hand side delivers water from a pump into the main feed pipe, and the second delivers it from an injector, but there is no check valve here, consequently if an attempt is made to start the injector while the pump is running, water is forced back to it and out at the overflow, thus preventing it from starting.

There is but one check valve provided for the two boilers, hence if both feed valves are open it is possible for water to be forced from one boiler into the other at a rapid rate. This would probably not happen if the boilers were connected properly by large steam pipes and carried the same pressure, as batteries have been operated for years with feed pipes arranged in this way. However, it is only fair to say that such an arrangement is not always satisfactory, even when the same pressure is supposed to be carried on both boilers, but this may be due to local conditions that would not apply to every case.

The boilers illustrated in Fig. 2 are operated under very different pressures as No. 1 supplies steam at high pressure for an engine with a fair load, while steam from No. 2 is used where a light pressure is sufficient, as it is not strong enough to carry more. Under these conditions this arrangement of pipes and valves is very inconvenient.

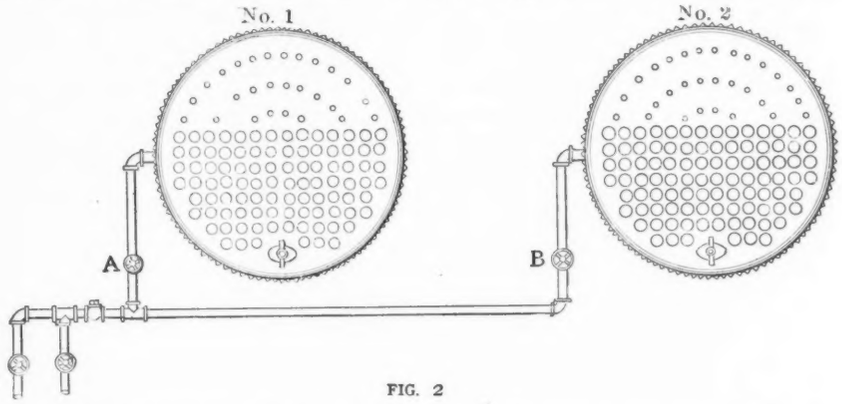


FIG. 2

For illustration suppose that water is going into No. 2, making it necessary to close the valve *A* in order to keep water in No. 1. When No. 2 has enough *A* must be opened and *B* closed as soon as possible, but before this can be done considerable water has passed from No. 1 into No. 2 especially if these are gate valves requiring many turns of the wheels to open and close them. This can be prevented by stopping the pump, closing *B* and opening *A* then starting the pump, but this is still more inconvenient.

Fig. 3 illustrates the improvement made by the above mentioned engineer. Each separate pipe for the pump and the injector is fitted with a check-valve, therefore if the pump does not supply enough water, the injector can be started at any

time without trouble. The valves *A* and *B* are for use in an emergency only. At all other times they remain open. The check-valves *C* and *D* prevent water from being forced back into the feed-pipe. Valves for regulating the supply of water to each boiler are shown at *E* and *F*.

In practice this arrangement of pipe and valves operates as follows. When starting the plant in the morning the valve *E* is opened and it remains open all day. As soon as water is wanted in either boiler the power pump is started, and if it is to be forced into No. 1 then *E* only is required to be open, but if No. 2 requires water it is only necessary to open *F* as all water from the pump will then go into No. 2 because pressure is much higher in No. 1, but none can be forced from one into the other under any conditions. From this description it will be plain that in order to regulate the feed for these two boilers, it is only necessary to open and close *F* from time to time. I do not present this plant as showing ideal conditions, but claim that this arrangement of valves and piping is the best that can be devised for the conditions described.

W. H. WAKEMAN.

New Haven, Conn.

Mr. Brand's Transformer Connections

Referring to my problem in the August number, the solution I adopted was to connect the primary windings also, and supply the two transformers from one phase of the primary line, as shown in Fig. 1. It would be impossible to connect them one to one phase and the other to the other phase because the currents rise

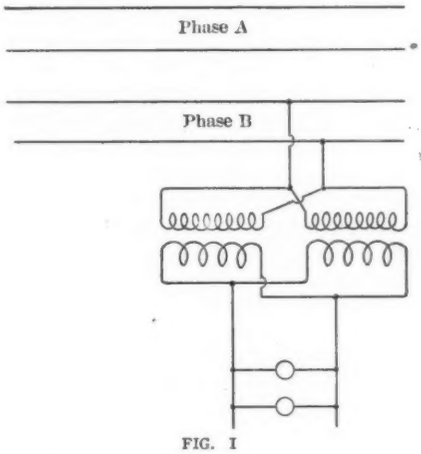


FIG. 1

and fall at different instants; when the primary current in phase *A* is maximum that in phase *B* is zero, and at that instant the secondary winding *b* would short-circuit the voltage of secondary *a* if the connections were as shown by Fig. 2.

H. B. BRAND.

Brooklyn, N. Y.

How Should Globe Valves be Placed?

Should a globe valve be placed with the steam entering above or below the disk? A few years ago I had charge of a plant where there was the usual stop-valve on the steam main close to the boiler, the steam passing through from the under side of the disk. One day a terrific rattling occurred suddenly near the valve, and as suddenly ceased. I concluded that the disk had become detached from the stem and was held up by the pressure, while the steam continued to flow to the engine without interruption. Examination proved this to be correct.

Some time afterward I had trouble with a 1½-inch valve on a pipe which supplied steam to some large kettles. When I attempted to open the valve one morning the wheel and stem turned freely but the pipe remained cold. I discovered that the disk had worked loose, and as the pressure was on top the disk was held firmly to its seat. There being no other valve between this and the boiler, repairing it was out of the question, so another pipe line had to be rigged up temporarily.

If the large valve first mentioned had been connected as was the second, when the disk dropped it would have shut down the entire plant.

S. WRENCH.

Brooklyn, N. Y.

Compounding an Engine

In 1902 my firm assumed charge of a dredge which had been unsuccessful, and found thereon two 15-inch sand pumps, each driven by a 20x30-inch balanced slide-valve engine. We determined to replace the two 15-inch pumps with a

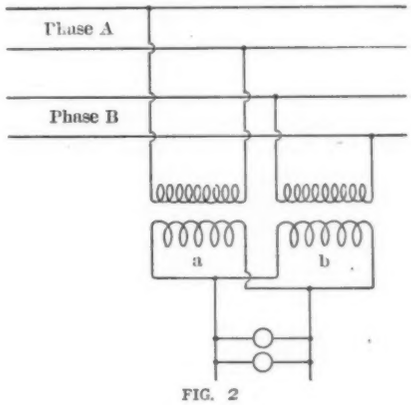


FIG. 2

22-inch pump, and replace the 20x30-inch cylinder on one of the engines with a 40x30-inch low-pressure cylinder, using the two as a 20 and 40 by 30-inch cross-compound engine.

We could not induce the builders of the engines to refit one of them with a large cylinder, because, they said, it could not be successfully done, owing to the fact that it would not go on the bed of the engine in the place of the old cylinder, and the valve-gear would not come right. We pointed out an easy way of altering the valve-gear to match a large cylinder and suggested having the cylinder overhang the bed, but all to no avail, as they said it would not be successful. We therefore went to a machine company and placed the order for the large cylinder, we assuming entire responsibility for the plans.

The two engines were placed side by side and both belted to one pump-shaft, but we did not connect them together otherwise, because of the difficulty of placing and holding them near enough in alinement on the more or less yielding deck to permit of rigid connection. Of course the exhaust steam was fixed from the high-pressure engine to the low-pressure engine, and from thence to the condenser.

This engine was run and gave satisfaction for perhaps a year when the piston and cylinder had become so worn on the bottom side that we could not keep the piston-rod packing tight. A brass shoe was then placed in the bottom of the stuffing-box for about 100 degrees of the circumference and the other 260 degrees was packed as usual. This shoe carries the entire weight of the piston and holds it in its proper position in the cylinder.

The rod is 4½ inches diameter, and as the cylinder overhangs the bed of the engine, and the old cylinder rested on the bed, there is about 4½ feet between the crosshead and this bearing when the engine is at the head end of the stroke, so the bearing is always nearer the piston it has to support than it is to the crosshead, which would not be the case in ordinary engines. This bearing or shoe has overcome all trouble with the low-pressure packing and the wearing down of the cylinder, and was in use about two years before we had to renew it.

There have been considerable comment and some adverse criticism upon this rig, especially because the two engines are not coupled, but we are entirely content as long as they run so satisfactorily.

Sometimes the engines run with the cranks opposite, sometimes quartering, sometimes together, and at all points between, but we can see no ill effects from this.

In regard to economy, I can only say that we now run the 22-inch pump doing more work than the two 15-inch pumps, with little more steam than it formerly took to run one of the 15-inch pumps, or, after making due allowance for the better economy of the larger pump, we consider that we are probably developing 65 per cent. more power with the same steam than one engine would formerly develop running condensing in both cases.

ELTON RISLEY.

Atlantic City, N. J.

POWER

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The Catalog Engineer

There is a supreme contempt on the part of some designers for what they term the "catalog engineer," and some funny things have certainly been done by men who have put up their shingles as "Mechanical Engineer," with no further qualification than their ability to take a more or less accurate indicator card and interpret it more or less correctly. When such a man is commissioned to design a steam plant his mode of procedure is to pick out from the catalogs of the makers of engines, boilers, pumps, electrical and other machinery, sizes listed as of the given capacity, and group them into a plant without any very comprehensive grasp of the actual requirements as modified by varying demand, etc., and no assurance of identity between the service of the projected plant and that upon which the catalog rating was based.

An exaggerated instance came under our notice recently, not exactly of the catalog engineer, for this was a member of the Institution of Civil Engineers and a retired engineer of the Royal Navy, but of dependence upon catalog ratings. The gentleman, notwithstanding his position and past attainments, had indorsed a fool proposition whereby more electrical energy was continuously taken out of a system of machinery than was furnished to it mechanically, basing his indorsement on the results of his own observations. When we interrogated him as to the methods employed in this revolutionary test, it appeared that he had read an ammeter and a voltmeter, to find the amount of power delivered, and taken the rated capacity of the engines out of a Westinghouse catalog as a measure of the power furnished; and with this flimsy equipment he had started out to upset the fundamentals of physical science.

But there is something to be said upon the other side. The genus "catalog engineer" may include men who, with an appreciation of the requirements of steam plants gained by experience, combine a wide knowledge of what is available in the different forms of apparatus, and a fund of "horse sense" regarding its suitability for certain classes of service, that cannot be perverted by the specious figuring nor the fervid eloquence of a department of publicity. Such a man having made up his mind what sort of an engine was required for a given situation would start out to buy such an engine, of the nearest standard size to his computed requirements, from a reputable builder; not to get up a set of drawings for an odd size embodying some notions of his own, and making his client pay four prices for something which is slightly if any betetr than the standard article would be. Yet those whose lips are the curliest when they mention the "catalog engineer" are those who cannot provide a scheme for piping up an oil cup without designing one or two special fittings.

You can step into a hardware store and buy a good screw-driver for a quarter. If you want one made to your own design and specification, it will cost something like four-fifty. It will probably be better than the ready-made article, but for only exceptional and rare instances can it be that much better.

Bearing in mind that the standing charges against a plant are a large proportion of the total expense, often equaling the fuel cost, and that these standing charges are proportional to the investment, is it not good engineering to avail oneself of the economies offered by aggregation and standardization, by the continued manufacture of an article in large numbers by special tools and machinery? And is not a man who has an extensive knowledge of what the market offers and what its capacities and limitations are, and a disposition to use what is available at a sacrifice of the pleasure of seeing his own ideals materialize at his client's expense, liable to be the satisfactory man in the long run even if he is open to the epithet "catalog engineer?"

Electrical Transmission of Power

At the last annual meeting of the American Institute of Electrical Engineers, held at Niagara Falls, E. J. Young read a paper in which he essayed to make out a case for single-phase alternating-current power transmission. Basing his figures on the maximum e.m.f. between line and ground, and on a system grounded at the central point of the step-up and step-down transformers, he showed that the single-phase line would require the same weight of copper as a three-phase line delivering the same power with the same loss; this, however, was a matter of common knowledge already. The further obvious facts that a single-phase line requires less expenditure for cross-arms and insulators and that stringing the wires costs less were also pointed out, and the author advanced the claim that in the event of trouble on one wire, the ground could be used as a return and operation continued at half voltage. This last claim is weak, but Mr. Young's plea that the switching facilities and transformer equipment would be greatly simplified in a single-phase plant, while trite, is a strong point—in fact, it was the strongest argument in his paper. However, in view of the many operating disadvantages of the single-phase system, prominent among which are the greater liability to surges and the impracticability of using large motors, it is not likely that electrical transmission practice will immediately retrograde to the use of the single-phase system.

Where Is the Long-heralded Alcohol Engine?

Notwithstanding the fact that the amended denatured-alcohol law goes into effect this month, there seems to have been little effort in the direction of developing alcohol motors. The relative fuel values of alcohol, kerosene and gasolene have been pointed out several times, and we all know about the continuous increase in the price of refined petroleum products due to the failure of the supply of crude oil to keep pace with the demand for its products. Nevertheless, the practical alcohol motor appears to be as undeveloped as before the question of denatured alcohol was raised.

The point has been made by several writers that starting an alcohol engine involves difficulties because the alcohol must be heated before it will volatilize with sufficient rapidity for use as fuel. This, of course, is a practical obstacle, but it must be overcome sooner or later and does not constitute a sound reason for neglecting the development of that type of engine. Moreover, it is an obstacle that should be overcome in several ways by the exercise of ordinary ingenuity.

Government Control of Water Powers

Our forebears sought to better their condition by coming to a land of plenty, where land could be had for the taking, where that which one created was his. Breaking away from a feudalism based upon the ownership of the soil, they could not foresee a feudalism equally absolute based upon the control of the supply and distribution of the necessities of life. The steam engine was uninvented, the factory system undreamed of, and nobody could predict the vast industrial empire of which coal, then a comparatively unimportant commodity, should be emperor.

Since that time there has developed an age of power and the country's fuel, the controlling factor of power production, is locked in the grasp of those who "saw it first."

But recent developments have made available as source of power the great, abundant, and widely distributed energy of falling water, and the waters of the State are within the control of the State, excepting where that control has been legislated away. Already the calendars of Congress and of the legislatures of the several States are loaded with bills conferring special privileges upon corporations and individuals to develop these natural sources of power for their own profit. Is the "white coal" to go the same way as the black, or will the people demand the retention of an interest in natural advantages made valuable only because they are here to use them?

New York has made a step in the right direction by adopting an act, introduced by Senator C. H. Fuller, which became a law on July 12, 1907, with the approval of the governor, authorizing and directing the State water-supply commission to devise plans for the progressive development of the water powers of the State for the public use, under State ownership and control, and making an appropriation therefor.

Etiquette in the Engine Room

An inquirer asks in the correspondence columns of our July number: "Would it be proper for an assistant engineer to take cards from engines during his watch, with his own indicator, without the consent of the chief?"

There is an implication in this that the chief is indisposed to grant his consent, for with matters upon the pleasant and mutually confidential basis which should exist between chief and assistant, there would not only be no question of consent, but the chief would congratulate himself upon having an assistant who was interested and progressive enough to own an indicator and want to perfect himself in its use.

It has been suggested that such permission might be withheld for fear that the assistant would presume to alter the adjustment of the valves, but this is not the question. Of course, no assistant should change the adjustment of an engine without consultation with the chief, nor without the chief's approval of his proposed setting. The chief is responsible for the safety, durability, quiet running and economy of the engines, and must have his way. The inquirer asks, not if it would be proper to change the adjustment of the valves, but if it is proper to take cards without the consent of the chief.

Another reason that has been suggested is that the chief might fear that the diagrams would expose some fault in his setting, or might enable the assistant to suggest improvements "over his head." If this were the case it would appear to us that it were time for the assistant (and the management, too, for that matter) to be looking for a new chief. It is the chief's business to get the best out of the plant that there is in it. He ought to be looking everywhere for chances of improvement. If an assistant can point them out to him, he should welcome his disposition and commend his ability to do so. Often a subordinate, through his close, practical contact with the work, and his continual chances for observation, is in a position to make valuable suggestions, and the chief who does not invite such a practice, and who belittles and repulses suggestions simply because they come from a subordinate, will not be so good a man in his position as one who encourages his assistants to think and talk with him about their work, and adopts and gives them credit for their suggestions when good.

On the other hand the assistant should not, because he is able to point out an occasional way in which things might be bettered, jump to the conclusion that he is a bigger man than the chief, and that he could hold the whole job down better than the chief is doing. Above all, he should not seek to attract favorable notice to himself and incur discredit to the chief by carrying his suggestions over the head of the chief to those in authority, before first referring them to the chief himself. Often the chief will be able to show him the utter impracticability or futility of something which looks to him like a great discovery, and it would be much less humiliating to have the chief do this first, than to have him called in to expose the mistake in front of the management.

To get back to the indicator cards, there is a reason which has not been heretofore suggested why the permission might be withheld. The management is frequently jealous of information regarding the operation of the plant. It would resent vigorously the finding of an indicator diagram from one of its engines in the hands of a competitor. Its relations with the engine builder as purchaser may be such as to be prejudiced by the exposure of a diagram from the engine, especially if it were open to criticism. If such diagrams were found in circulation the chief, not the assistant, would be blamed. If you have a chief who is otherwise decent, don't condemn him if he refuses to let you use an indicator. He may have good reasons of which you do not know.

The Price of Anthracite Coal

We have received from a "publicity" house, released for publication on receipt of copy, a frantic effort to justify the increased price of anthracite coal.

Almost simultaneously comes a statement from the anthracite-coal operators commenting upon the work of the board of conciliation and the present peaceful conditions in the anthracite fields, and containing the statement that "for every advance of five cents above a tidewater selling price of $4.50 for domestic sizes, there is an increase of one per cent. in the wages of every miner." As a miner mines some ten tons of coal per day and gets about four dollars for it, his increase would amount to about 0.4 of a cent per ton for every extra nickel taken from the consumer. Even if his helpers got a proportionate increase, their combined labor would receive less than a cent. What becomes of the other four?

Williams Vertical Compound Duplex Engine

The Williams vertical compound duplex steam engine is intended for situations where less than 500 horse-power in a single, high-speed unit is desired. The aim of the designer is not only to secure high speed and good steam economy, but to use few and simple running parts with ample wearing surfaces, to permit thorough lubrication with general cleanliness, to effect a running balance at any speed, and to make the exterior pleasing to the eye.

This engine is of the self-contained and self-oiling, inclosed type, with two sets of reciprocating parts, the object of the duplex feature being, primarily, to admit of doubling the power at any given rotative speed and to enable a running balance to be established, both being essential to the objects of the design, and, incidentally, to admit of very simple and abbreviated valve systems.

There are two low-pressure cylinders, close side by side, formed with their valve chests in a single casting and secured to the housings by bolts. Directly above each low-pressure cylinder is a high-pressure cylinder of smaller bore, with its lower end opening full size into the low-pressure cylinder immediately below and in line with it. See Fig. 2. The two high-pressure cylinders are formed by bushings pressed in a casting common to both.

Within each set of cylinders thus formed and arranged is operated a single piston the upper part of which is of right diameter to operate in the high-pressure cylinder bore. These are the high-pressure pistons. They are single-acting. At the lower ends of these trunks enlarged portions of the same castings form the low-pressure pistons, fitting the bores of the low-pressure cylinders. The low-pressure pistons are double-acting, steam being admitted to and exhausted from each side, above and below. From these pistons the piston-rods extend downward through the stuffing-boxes to the crossheads. The pistons are packed with limited-expansion rings.

The crossheads are of cast iron and as light as is consistent with strength. The guide-shoes are unusually large, chilled on their faces and ground to perfect forms and proper fit. They are practically indestructible by use and do not require re-adjustment. The wrist-pin boxes are of hard-wearing material and are amply large.

The connecting-rods are of cast steel, the upper ends forked, carrying the wrist-pins. The lower ends form the upper halves of the crank-boxes, the lower halves being held in place by through bolts, according to marine practice. The crank-boxes are lined with heavy-duty metal. The crank-pins are forged in one piece with the shaft and are set opposite, or at 180 degrees. Their diameters are the same as those of the main journals.

The cranks are forged on the shaft and the two outer ones are counterweighted, the weights being secured in position by tongues and bolts. The crank-shaft is of forged steel, with two main journals of ample diameter and length. In this design the third or center bearing is not required, as the low-pressure pistons are double-acting and close together. To prevent springing, the intermediate shaft is of great strength, the eccentrics being forged on, admitting of unusual section at this point, where required for stiffness. On account of the closeness of the cranks to each other, their opposite movements and the double-acting and differential feature of the low-pressure pistons, wherein the larger area is acted upon by the steam on the upward movement, the steam forces are largely converted into a twisting effort.

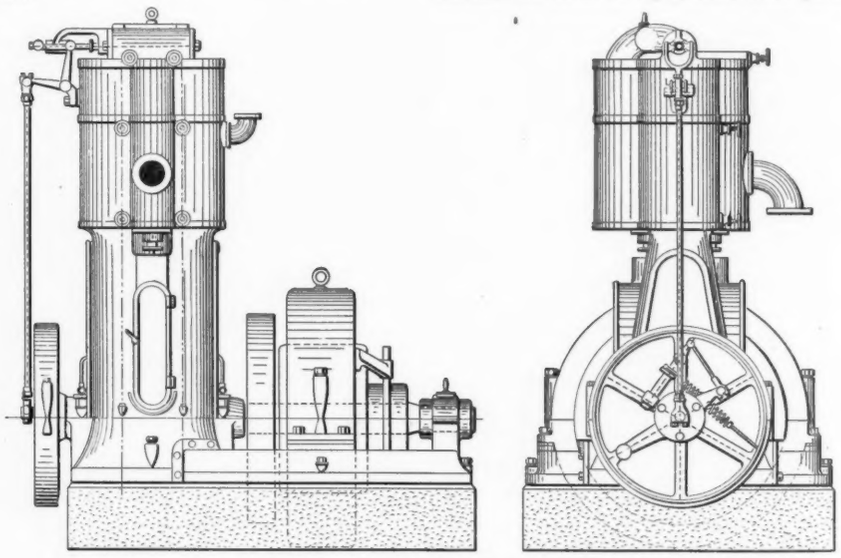


FIG. 1. SIDE AND END ELEVATIONS

When an outer bearing is used, it is to be provided with oil-ring lubrication, lined with genuine babbitt metal and so constructed as to retain the oil. The main frame is so formed as to retain the oil, and is provided with removable or hinged doors to admit of free access to the interior working parts.

Extended sub-bases of the box form are provided when required for sustaining the outer bearing, or generator, centrifugal pump, or other machine to be direct-driven.

The governor is mounted on one of the shaft extensions and operates, from a pin, the high-pressure valves, as shown in Fig. 2. These are the only exterior working parts and the revolving wheel is neatly incased by an oil-guard of cast iron or sheet steel secured to the outer end of the main bearing adjacent to it. The governor is of the single-arm gravity-balance type, and all bearings subject to wear are adjustable.

The valves are of the piston type and are provided with self-adjusting packings so constructed that no unnecessary friction is occasioned in making them steam-tight. The wear is slight and the packings automatically follow up what wear there may be. They operate in cast-iron bushings, with milled ports reamed true to size and adjustment after having been pressed into position.

There are three valve systems: one for the high-pressure steam and exhaust, another for the low-pressure steam, and one for the low-pressure exhaust. See Fig. 3. As the steam enters one of the high-pressure cylinders it exhausts from the other. In Fig. 2 the valve is moving to the left, just admitting steam to that cylinder and exhausting freely from the right-hand cylinder. By referring again to Fig. 3, it will be seen that a passage is provided for this exhaust steam to the receiver-separator (also shown in section in Fig. 5), being circular in form and provided with partitions dividing the area into four spaces. The steam first enters the space farthest from the cylinders, passes down to the bottom, through openings into the two side spaces, then into the nearest space and down into the low-pressure steam chest. This chest is provided with one valve at the top and one at the bottom, for admitting steam to both low-pressure cylinders. When in the positions shown and moving upward, the lower valve is admitting steam to the lower end of one cylinder, while the other valve is admitting steam to the upper end of the other cylinder. When the crank-shaft has made a half revolution, these admissions will be just reversed; so each valve serves two cylinders. The exhaust operates in like manner. From the exhaust chamber the steam enters the exhaust pipe.

Before entering the high-pressure steam chest, the steam passes through the steam jacket formed in the high-pressure cylin-

der casting. The place of admission to the jacket, or high-pressure connection, is shown to the left in Fig. 2, in the upper part of the low-pressure casting. It is placed in this locality so the high-pressure cylinders may be removed without disturbing the steam pipe. Soft copper joints are used between the cylinders. It will be seen that the high-pressure cylinders are bushings pressed into the cylinder casting, with steam-jacket space all around. The receiver-separator is constructed and jacketed in the same manner.

There are only two stuffing-boxes required for the piston-rods, and they are subjected to low pressures. These packing chambers are metallic-packed. Just below the metallic packing there are condensation chambers (piped to the exhaust) and below these there are soft packings to keep the rods entirely free from water leakage. The valve spindles (packed against low pressure, also) are to be soft-packed. No rods are subjected to high pressures.

The lubrication is accomplished by a pump located in a sump in the bottom of the crank-pit, from which the oil is forced up through pipes to the upper ends of the guides, where it is delivered. A portion of the oil flowing down the faces of the guides is caught in pockets in the faces of the crosshead shoes and conveyed through tubes to the wrist-pin bearings, the rest flowing into receptacles at the lower ends of the guides. From two of these the oil is piped to the eccentrics, and from the other two to the main bearings, which are so constructed that the oil must leave by the ends next to the cranks, where it is caught by an oil-catch and delivered to the crank-pins. Exterior working parts are provided with grease cups, and all exterior hot surfaces are protected by non-conducting coverings. All is incased with sheet steel.

Reheating pipes may be placed in the low-pressure steam chest, as shown in Fig. 3, adding superheat to the steam after it leaves the receiver, in which case the drain from the steam jacket is taken through these pipes in series, so as to insure circulation.

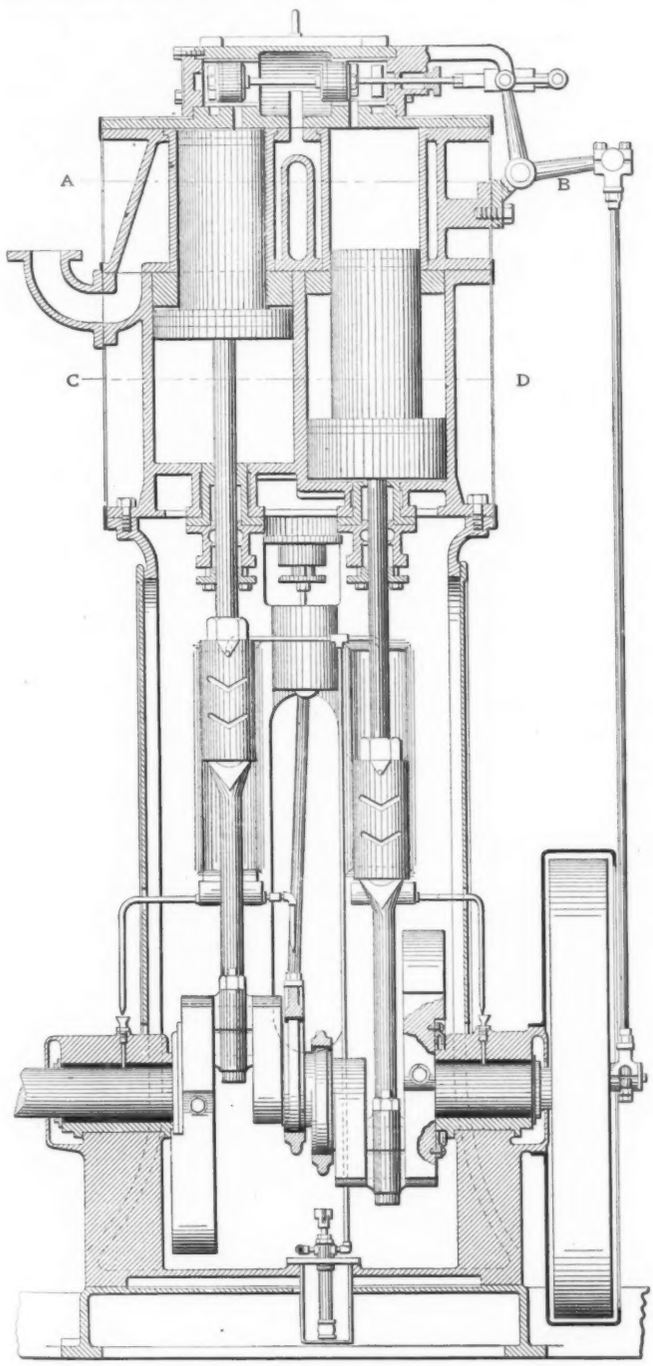


FIG. 2. SECTION THROUGH CYLINDERS

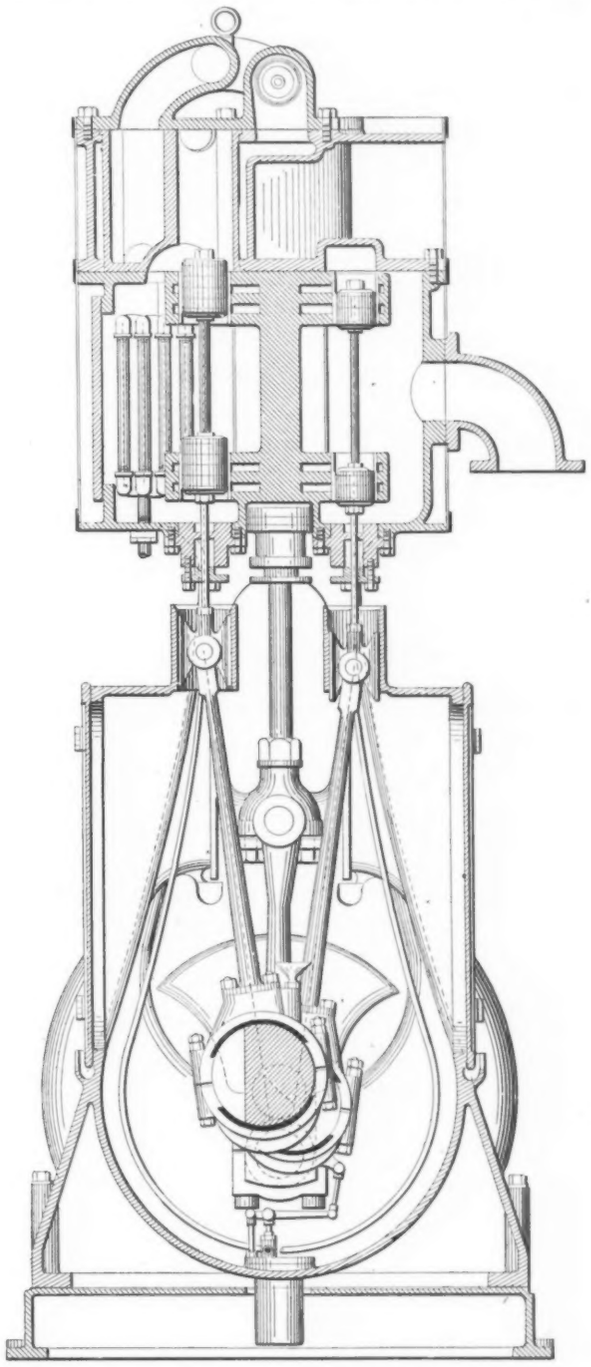


FIG. 3. SECTION THROUGH VALVE CHESTS

The distribution of steam pressures in the steam cylinders at normal load is illustrated by theoretical diagrams presented in Fig. 6. These are characteristic of the engine under the following conditions:

Revolutions per minute, 340;
Working cylinder ratio, 4.

In constructing these diagrams, allowances were made for reduction of pressures due to velocity of steam through the ports and passages. No allowance was made for condensation or re-evaporation. The customary fall of 10 pounds (due to the single-valve system) in pressures between the steam pipe and the closing of the valve at cut-off is assumed. The fall of pressure due to the early opening of the exhaust (due to the single-valve governor control, also) on the high-pressure cylinder, is made gradual by rightly proportioning the port area to the piston. The exhaust closure, being controlled by the governor, takes place at an early point when the cut-off is early, and at a late point when the cut-off is late. These features of the single-valve movement serve to effect an almost constant ultimate compression under varying loads. The cut-off on the low-pressure being fixed, the receiver pressures (from which the compression begins) vary with the cut-off and the exhaust closure, being lowest when the exhaust closure is earliest; so the compression is always carried up to nearly the same point at all loads. This would not be the case if the cut-off were variable on the low-pressure cylinder also. In that case the receiver pressure would be constant and the compression would vary to such an extent as to make the single-valve system impracticable.

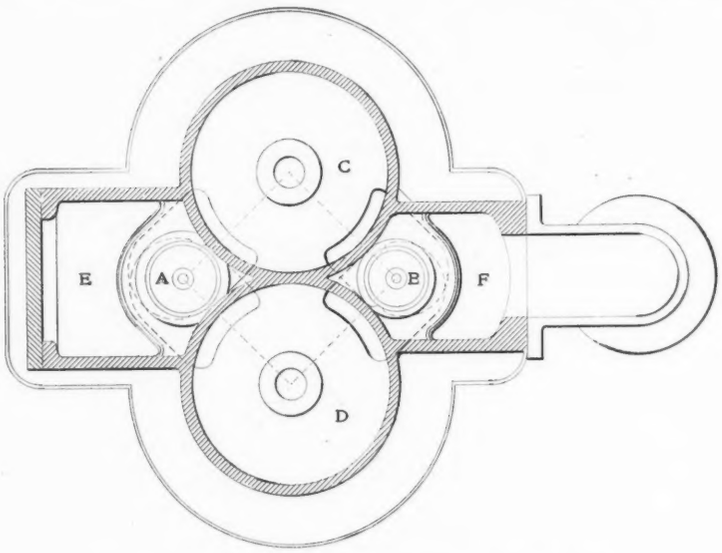


FIG. 4. SECTION (C-D, FIG. 2) THROUGH LOW-PRESSURE CYLINDERS

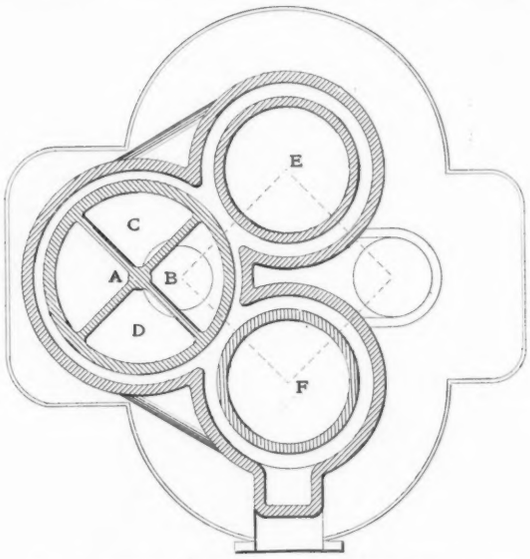


FIG. 5. SECTION (A-B, FIG. 2) THROUGH HIGH-PRESSURE CYLINDERS AND RECEIVER

Pressure in steam pipe, 140 pounds;
Vacuum in exhaust pipe, 26 pounds;
Point of cut-off in high-pressure cylinder, 30 per cent.;
Point of cut-off in low-pressure cylinder, 40 per cent.;
Clearance in high-pressure cylinder, 5 per cent.;

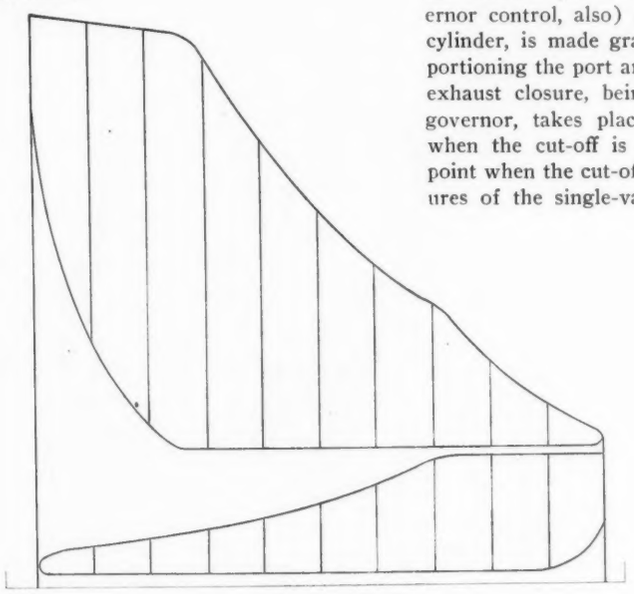


FIG. 6. THEORETICAL STEAM DIAGRAMS

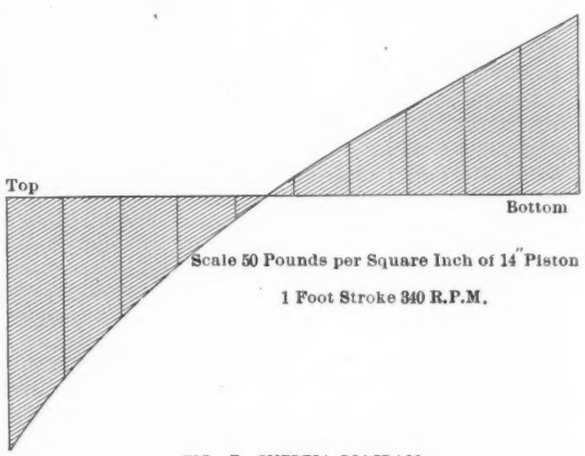


FIG. 7. INERTIA DIAGRAM

Clearance in low-pressure cylinder (mean), 3 per cent.;
Diameters of cylinders, 9 inches and 14 inches;
Stroke, 12 inches;

The fixed cut-off and varying receiver pressures are admirably suited to single-valve governor control on the high-pressure cylinder, as described. The low-pressure diagram is such as may be expected from any well-designed low-pressure cylinder with small clearance. Comparatively little compression is intended.

Prominent features favoring economy in the use of steam may be briefly stated as follows: High speed, low cylinder clearances (3 to 5 per cent.), steam jacket, reheating-separating receiver, short direct ports, protection of hot surfaces from external radiations of heat, steam-tight and free-moving valves and pistons, and a

valve system favoring high mean effective pressures for any given initial cylinder ratio and point of cut-off.

The effects of inertia in the reciprocating parts (increasing as the square of the rate of rotation) is developed to such a degree at high speeds, and plays such an important part in the serviceability of the reciprocating high-speed engine, that any such design would be incomplete without an inquiry into its effects upon the bearings, especially the crank-pins, which may be subjected to or freed from more or less wear by its existence; and its effects upon the smoothness of operation at the centers, tending to increase or decrease the friction, or pounding, as the case may be, and the degree of looseness, or slack, of bearings that may be permissible in "quiet" running. The life and serviceability of the engine depend largely on these points.

Assume a Williams "Monogram" engine with 9x14-inch cylinders, stroke 12 inches and speed 340 revolutions per minute, with weights of the reciprocating parts about as follows: piston, piston-rod and nut, 300 pounds; crosshead, 70 pounds; connecting-rod, complete, 90 pounds; total weight, 460 pounds.

The centrifugal force developed at the crank-pin at 340 revolutions per minute will be

$$\frac{340^2 \times 1}{5870} = 19.2,$$

which is the force per unit of weight. The weight in this case being 460 pounds, the total mean centrifugal force exerted at the centers (ends of stroke) is

$$19.2 \times 460 = 9012 \text{ } pounds.$$

The connecting-rod length in these engines being 2¾ times the stroke, the inertia at the upper end of the stroke would exceed the centrifugal force by about 17 per cent., falling short the same amount at the lower end of the stroke, and the inertia force at the top would be:

$$9012 \times 1.17 = 10{,}544 \text{ } pounds;$$

and at the bottom:

$$9012 \times 0.83 = 7480 \text{ } pounds.$$

The area of the low pressure being 150 inches net, the inertia per square inch of the low-pressure piston, at the top, is:

$$10{,}544 \div 150 = 70.0 \text{ } pounds;$$

and at the bottom:

$$7480 \div 150 = 49.8 \text{ } pounds.$$

The inertia diagram Fig. 7 is drawn to conform to these figures. Taking the steam forces as shown on the indicator diagrams: The total opposing steam force at the top center is 11,520 pounds, just about 1000 pounds in excess of the inertia, or $1000 \div 150 = 7$ pounds, nearly, per square inch of the low-pressure piston, which is the exponent of the blow received by the crank-pin at upper center at the time of the admission of steam. This is very light and the engine would pass that center very comfortably without being keyed up dangerously close. In like manner it will be found that at the lower center the inertia *exceeds* the steam force by about 2900 pounds, or approximately 18 pounds per square inch. By following the inertia curve from the bottom end, it will be seen that the inertia pressure is reduced to equal the steam force at about 20 per cent. of the upward stroke. This is where the reversal of pressures on the crank-pin would take place. It would be accomplished gradually and there would be no tendency to pounding. The inertias developed in this engine are not excessive, but sufficient to insure smoothness of operation and freedom from excessive friction.

E. F. Williams, 42 Broadway, New York, was the designer of this engine.

The Melms-Pfenninger Combined Impulse and Reaction Turbine

By R. Stresau

A turbine combining the impulse and reaction principles has been placed on the market by Melms & Pfenninger, of Munich. The general appearance and construction of the turbine are shown in Figs. 1 and 2. The high-pressure steam is expanded down to about 30 pounds absolute in the action or impulse part, marked *A* in the diagram Fig. 2, whose guide blades occupy but a portion of the circumference; the rest is blocked off, thus obtaining partial admission. The steam then enters the reaction part and expands to the pressure in the condenser. Since the impulse principle allows of partial admission, the diameter of the impulse part can be so chosen that the pressure on the annular surface, formed by the difference in the diameters of the impulse part and the first section of the reaction part, is just enough to counterbalance the axial thrust of the reaction part. The regulation is obtained by throttling, so that the pressure on the annular surface and the thrust from the reaction part are always proportional to the load and counterbalance each other at all loads. The annular ring and the difference between the impulse and the reaction blades are plainly shown in Fig. 3.

Fig. 4 is a diagrammatic representation of the pure reaction parallel-flow turbine; Fig. 5, a Melms-Pfenninger type of the same capacity. These diagrams show the decrease in length and the increase in stiffness of the drum gained by the combination of the two principles. In the pure reaction type the blade length decreases approximately with the square of the increase of the drum diameter.

The clearance, for practical reasons, remains constant, so that with an increase of the drum diameter the leakage due to the clearance over the blade-tips grows with the square of the increase in the drum diameter. A drum diameter such as is used in the new type turbine of 1000 kilowatts capacity and running at 1500 revolutions for the high-pressure end would result in blades so short that the necessary clearance of about 0.02 to 0.03 of an inch would be relatively great and the steam leakage prohibitive.

The reduction of the drum diameter results in longer blades with allowable steam leakage over the blade-tips, but also in a decrease in the blade velocity. To maintain the best relation between blade velocity and steam velocity, the energy (which is dependent on the steam velocity) converted in each row of blades must be reduced. Consequently, a greater number of rows of blades must be used, resulting in a long drum. Two serious faults arise: whipping of the drum due to the large deflection of a drum whose diameter is small at its middle, and warping of the casing due to the changes of temperature to which it is subjected. Therefore, to avoid stripping of the blades, the clearance between the tips of the blades and the casing or drum, respectively, have to be made greater than would otherwise be necessary.

Experience with the reaction turbine has shown that the stripping of the blades nearly always occurs at the second or third section of the first stage, that is, at the middle of the drum, due apparently to the deflection of the drum, or warping or "hogging" of the casing. It is also a conceded fact that the high-pressure stages of the pure reaction turbine are much less efficient than the low-pressure stages, due to the excessive leakage losses. It has been the aim of the designers of the Melms-Pfenninger turbine to take advantage of the high practical efficiency of the reaction principle for low pressure, and to supplant the high-pressure reaction stages by a construction which would give greater stability and safety with at least the same efficiency. This has been accomplished by employing the impulse principle with partial admission.

Fig. 5 shows the decrease in length and greater diameter of the Melms-Pfenninger drum, resulting in greater stiffness. The distance between bearings is 35 per cent. less and the smallest diameter is 1.7 that of the smallest part of the reaction turbine. In consequence the deflection of the Melms-Pfenninger drum is at the maximum one-fifth of the deflection of a corresponding reaction-turbine drum. Therefore, with the same clearance, the length of the blades is greater, and, due to the stiffness of the drum, the danger of stripping is very much decreased.

In comparison to the pure impulse type, this turbine has several constructive advantages, due to the fact that the steam in

the impulse part is expanded down to only about 30 pounds absolute, the remaining expansion being taken care of by the reaction part, which is superior to the impulse system for low pressures.

Steam expanding from 170 pounds to 1.4 pounds absolute (assuming dry steam) has about 120 times its initial volume. In the usual construction of the impulse turbine the energy of this expansion is converted into work in 10 to 11 rows of moving blades. If the critical expansion $\frac{P_1}{P_2} = 1.7$ is maintained, which is usually done to keep the number of rows as low as possible, the pressure difference which must be taken care of by the packing glands is about 70 pounds between the first and the second row, the pressure decreasing as the initial pressure for each row decreases. Furthermore, a steam velocity of 1500 feet per second results. In the Melms-Pfenninger turbine the steam expands from 170 to 30 pounds absolute, or to 6 times its initial volume in the impulse part. If the energy of this expansion is converted into work in 10 rows, the difference in pressure is much less since the relation $\frac{P_1}{P_2}$ can be chosen much smaller and a steam velocity of about 660 feet per second results.

The small pressure difference noted above can be easily taken care of by a simple gland situated directly on the drum, and the complicated gland on the shaft between the disks as usually constructed is avoided. Also the small steam velocity results in comparatively small losses due to fluid friction, since these losses are proportional to the square of the steam velocity. The drum construction, since it affords far less surface than the disk construction also reduces the fluid friction.

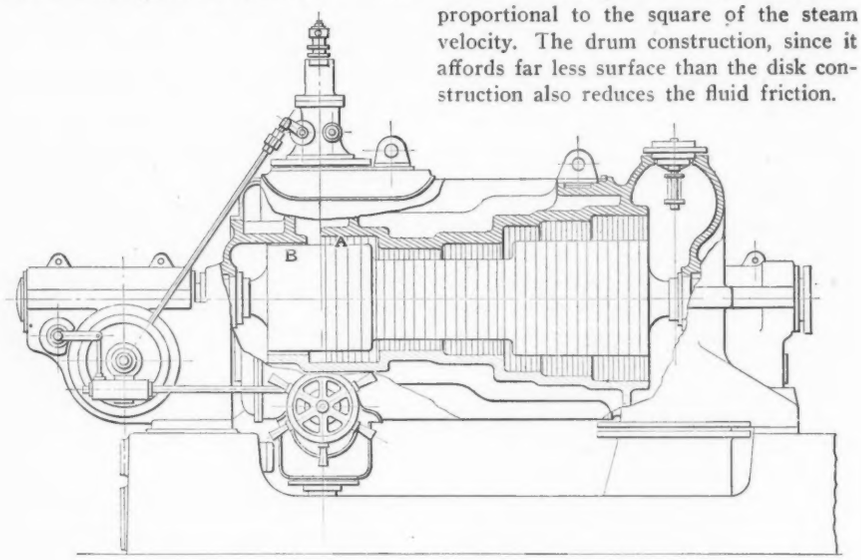


FIG. 2. SECTIONAL VIEW OF MELMS-PFENNINGER TURBINE

The drum is made of cast steel in one piece in which grooves are machined for the blading and packing glands. The blades are drawn from special bronze;

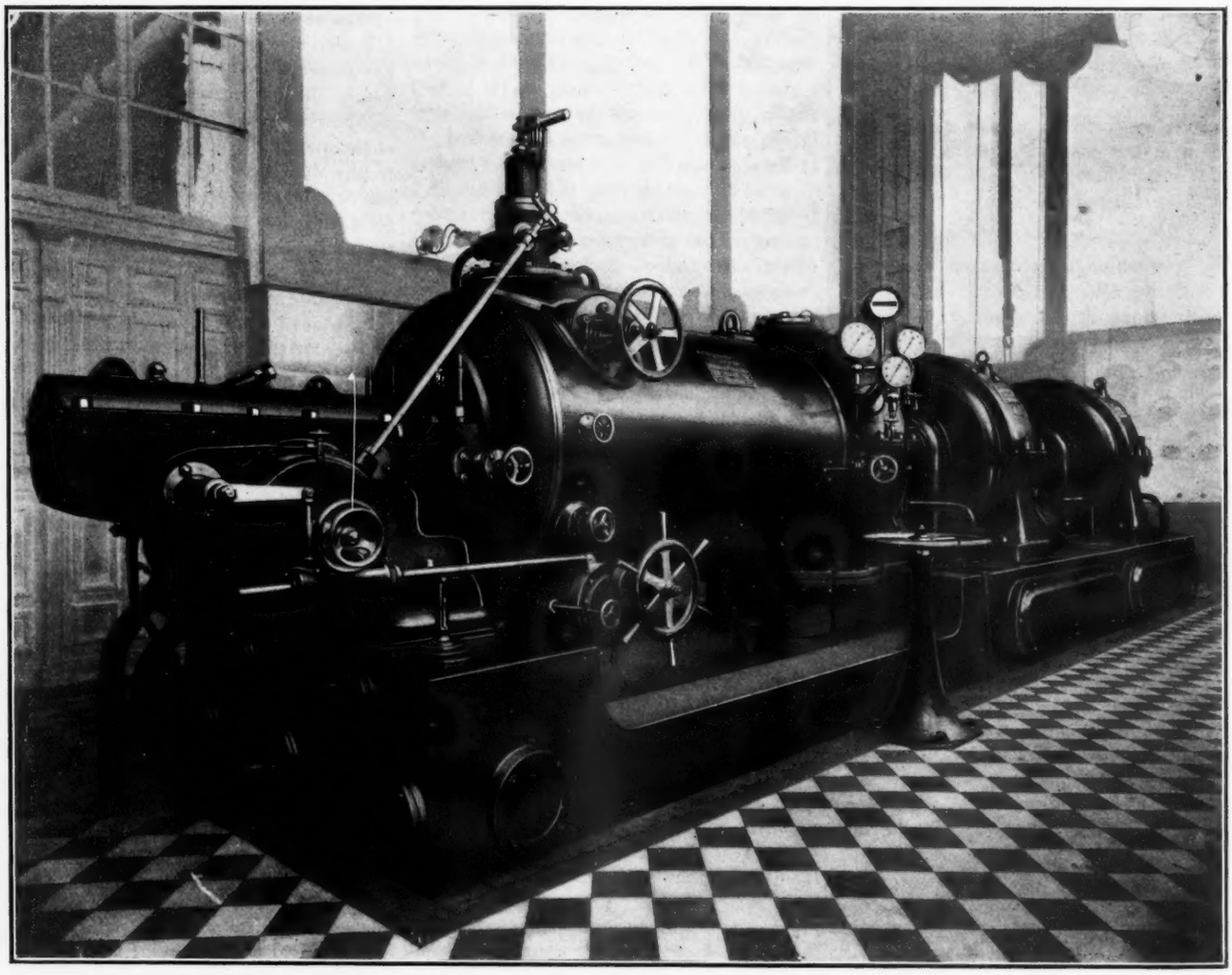


FIG. I. THE MELMS-PFENNINGER COMBINED IMPULSE AND REACTION TURBINE

those which are subjected to high superheat are made of special steel.

The auxiliary parts of the turbine have been reduced to such simple and compact design as safety and good working

FIG. 3. SHOWING ANNULAR RING AND BLADES

will allow. At the high-pressure end the main valve and throttle valve are situated below and above the cylindrical casing, respectively (see Fig. 1), connected by two steam pipes which surround the casing and help to keep the temperature of the cylinder uniform. The hand-wheel just below the throttle valve operates the overload valve, which opens a by-pass so that the high-pressure steam can be applied directly to the reaction part of the turbine. An overload of 50 per cent. can be carried in this way.

At the part marked *B*, Fig. 2, a series of labyrinth glands prevents the high-pressure steam from escaping in that direction. Two stuffing-boxes of the labyrinth type, fed with the exhaust steam from the throttle valve, are placed at each end of the casing and surround the shaft where it leaves the casing. These packing glands prevent the air from entering the interior of the turbine.

The rotor is carried by two main bearings which have several superimposed shells with play between. Grooves and holes in the shells also help to distribute the oil so that the shells practically float in it, its viscosity opposing the forcing out of the oil when vibration occurs, and this yielding resistance acts as a cushion. An adjustable thrust-bearing is also provided to adjust the axial play of the moving blades with reference to the fixed blades and the clearance of the packing glands; also, to take up any axial thrust due to the generators or other exterior causes.

At the high-pressure end of the shaft a safety speed-governor is fixed which prevents any undue increase in the revolutions by tripping the main valve by means of the linkage shown in Fig. 1.

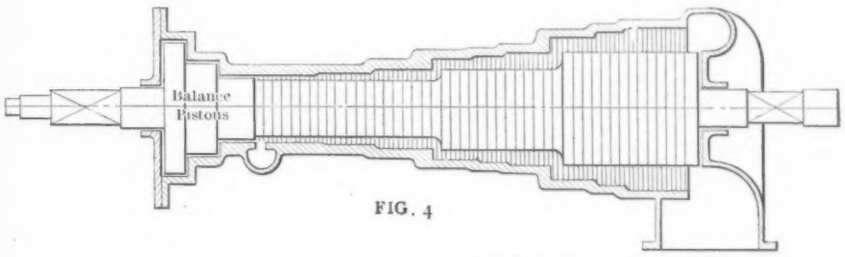


FIG. 4

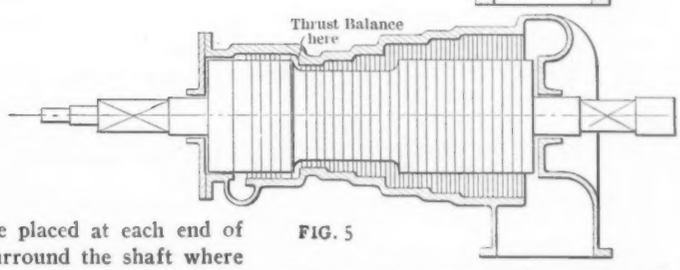


FIG. 5

Between the main bearing at the high-pressure end and the thrust-bearing is a worm which drives a worm-wheel on a shaft below and at right angles to the main shaft. The shaft governor incased by the circular cover on the front side and the pressure oil-pump at the rear are placed on this secondary shaft. The pressure oil-pump provides oil at 20 pounds pressure for the turbine bearings, gover-

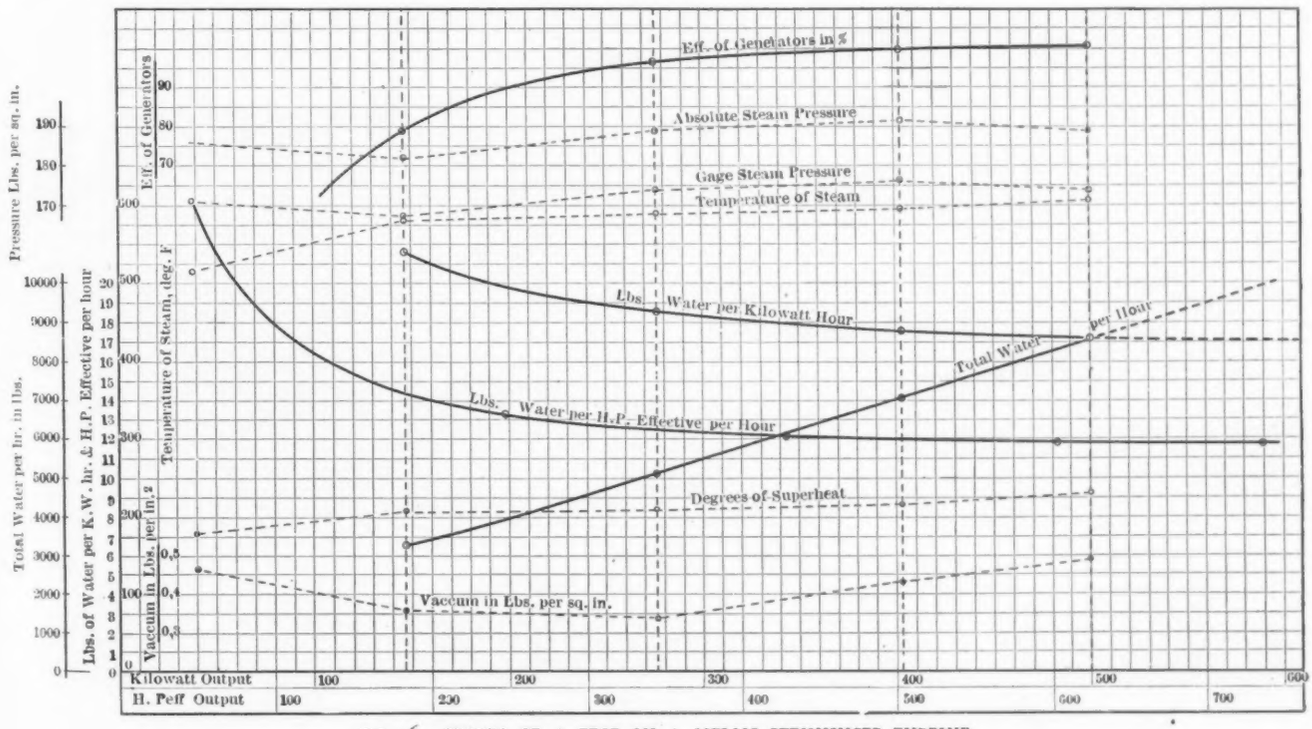

Eff. of Generators in %
Absolute Steam Pressure
Gage Steam Pressure
Temperature of Steam
Lbs. Water per Kilowatt Hour
Total Water per Hour
Lbs. Water per H.P. Effective per Hour
Degrees of Superheat
Vaccum in Lbs. per sq. in.
Pressure Lbs. per sq. in.
Eff. of Generators
Temperature of Steam, deg. F.
Vaccum in Lbs. per in.²
Total Water per hr. in lbs.
Lbs. of Water per K.W. hr. & H.P. Effective per hour
Kilowatt Output
H. Peff Output

FIG. 6. CURVES OF A TEST ON A MELMS-PFENNINGER TURBINE

nors, thrust-bearings and generator bearings. The shaft governor, by means of an eccentric whose eccentricity is variable, gives the sloping rod coming from the circular cover, Fig. 1, a variable reciprocating motion. This motion turns a rotary valve which controls the steam pressure under, and hence the position of a piston to which the throttle valve is fixed.

The accompanying table and the chart Fig. 6 give the results of a test made by Professor Dr. Schroter on a Melms-Pfenninger turbo-generator set running in the power house of the locomotive works of J. A. Maffei, Munich. The set shown in Figs. 1 and 2 consists of a 1000-horse-power turbine with two direct-current direct-coupled generators of 250 kilowatts output each, at 250 revolutions per minute. The values given are those at the switchboard, but they do not include the work consumed by the condensing plant. The consumption of steam per kilowatt-hour at the maximum output of the generators is 17.2 pounds. The dotted portions of the curves have been extra-polated, which seems allowable, considering the regularity of the curves, so that the consumption at the normal rating of the machine as shown by the dotted line is 16.9 pounds per kilowatt-hour.

The last three lines of the table give the effective work of the turbine; that is, the output at the switchboard has been divided by the efficiency of the generators. The work consumed by the condensing plant is not included in the output of the turbine. The consumption of steam at the maximum output of the generators is thus 11.7 pounds, and at the rated capacity of the turbine 11.6 pounds per electrical horse-power-hour.

The increase in pounds of steam per kilowatt-hour with diminishing load is as follows, the current being measured at the switchboard:

Trial number	1	2	3	4
Load	100.0	80.0	56.0	30.0
Condensed steam per kilowatt	17.2	17.5	18.5	22.5
Condensed steam per kilowatt in per cent	100.0	101.8	107.7	130.8

In these values the decreasing value of the efficiency of the generators increases the steam consumption per kilowatt-hour. If the steam consumption per electrical horse-power is used, the following values are obtained:

$$\frac{\textit{lb. of steam per H.P.}_e = \textit{lb. of steam per kw.-hour} \times n}{1.34}$$

Trial number	1	2	3	4
Load in per cent. of maximum	100.0	80.0	56.0	30.0
Condensed steam in lb. per hour per H.P$_e$	11.7	11.8	12.1	13.4
Condensed steam in lb. per hour, per cent.	100.0	100.1	103.5	114.5

The values show the exceedingly small increase with even 30 per cent. of the normal load shown, also by the flatness of the curve marked pounds of steam per *H.P.*$_e$, Fig. 6.

A number of turbines are now being constructed at the Maffei works and it is hoped to surpass the results of the first turbine in regards to both steam consumption and design.

TABLE SHOWING RESULTS OF TEST OF A MELMS-PFENNINGER TURBO-GENERATOR SET AT THE WORKS OF J. A. MAFFEI, MUNICH.

	I	II	III	IV	V	VI	VII
Load in round numbers, kw	500.0	400.0	280.0	150.0	Running Light		
Load in round numbers in per cent. of max. load	100.0	80.0	56.0	30.0	Both Excited.	Generators Not Excited.	Turbine Only.
Average number of revolutions per minute	2459.0	2469.0	2477.0	2489.0	2516.0	2535 0	2505.0
Absolute steam pressure at main valve of turbine, lb. per sq.in	189.0	191.5	189.0	182.0	186.0	186.0	186.0
Steam pressure above atmospheric (gage pressure), lb. per sq.in	174.0	176.0	174.0	167.0	171.0	171.0	171.0
Actual temperature of steam, deg. C	319.4	312.4	308.2	306.2	289.2	286.0	238.0
Actual temperature of steam, deg. F	607.0	594.0	587.0	583.0	553.0	546.0	460.0
Superheat, deg. F	230.0	216.0	210.0	209.0	177.0	170.0	84.1
Vacuum, absolute pressure in lb. per sq.in	0.484	0.43	0.34	0.36	0.47	0.48	0.55
Output measured at switchboard, kw	499.0	403.0	278.0	147.0			
Consumption of steam per hour	8580.0	7056.0	5144.0	3300.0	1227.0	1056.0	582.0
Consumption of steam per kw.-hour	17.2	17.5	18.5	22.5			
Efficiency of generator	0.906	0.897	0.870	0.791			
Output of turbine, kw	550.0	449.0	319.0	185.0	35.9	25.7	
Output of turbine, H.P$_e$	738.0	602.0	427.0	248.0	48.0	34.0	
Consumption of steam per H.P$_e$.-hour	11.7	11.8	12.1	13.4	25.8	30.9	

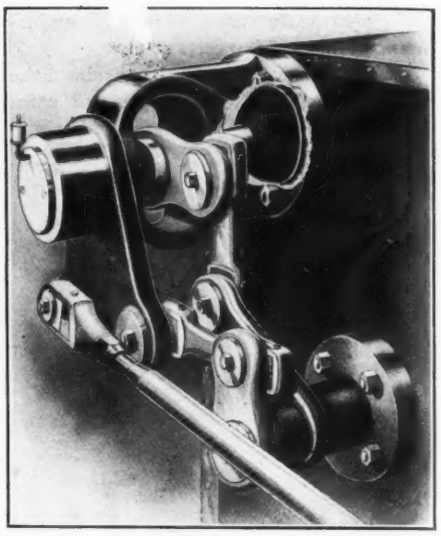


FIG. 2. VALVE GEAR; SHOWING ALSO SPECIAL BALL PACKING

Hooven, Owens, Rentschler Company's Type HS High-speed Corliss Engine

This engine is made from the company's regular Corliss patterns with the exception that the strokes are shorter, the dashpots are eliminated, the valve-gear is positive-driven, and the governor is of the inertia type located in the wheel. The engine is made in all sizes upward from 50 horse-power, in the single-cylinder, tandem and cross-compound types, horizontal and vertical. The range of speed is from 125 to 200 revolutions per minute.

The frame or bed is brought down to the floor and no foundation nor sub-base is needed above the floor line. The cylinder is supported upon feet bolted to the foundation and is not overhung.

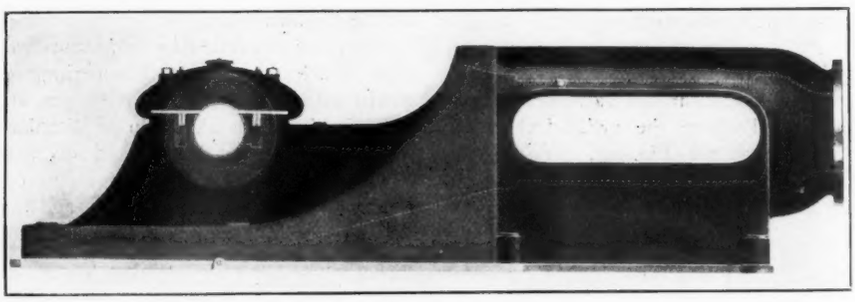


FIG. 1. SIDE VIEW OF FRAME

For actuating the valve-gear, instead of rocker plates, a system of bell-crank levers is used. The valve-stems have long bearings in the brackets, the steam valve-stems being supported at both sides of the valve-cranks. The latter have split hubs and in addition to being firmly clamped to the stems are keyed to prevent liability of becoming loose.

Reference to Fig. 4 will show that the exhaust valve-gear is brought very close to the cylinder, and this is likewise true of the larger part of the steam valve-gear. Fig. 5 shows the arrangement of the exhaust valve-gear more clearly.

On the interior of the cylinder is used a special metallic valve-stem packing, as shown in Fig. 2, obviating the necessity for outside stuffing-boxes and glands. This type of packing readily adapts itself to surrounding conditions, thereby reducing friction, and by eliminating valve-stem

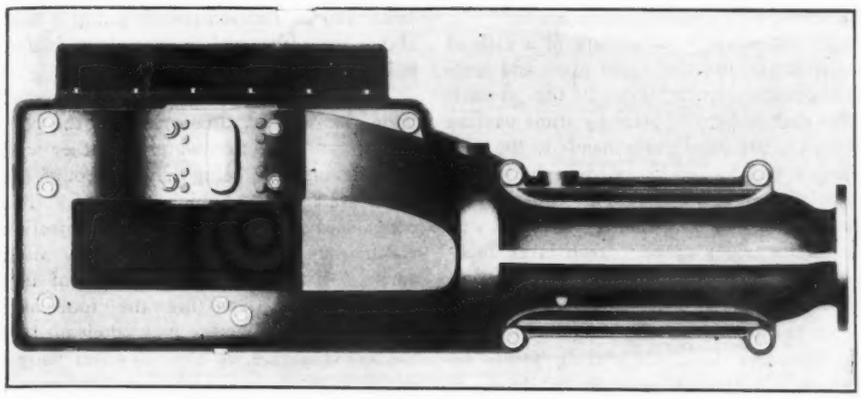


FIG. 3. PLAN VIEW OF FRAME

packings prevents drip and leakage from that source.

The company's standard double-ported Corliss valves are used, but valves are not placed in the cylinder-heads, unless by special request, as it is not believed that the slight gain in economy will offset the trouble caused in removing the head. Also, leakages caused by unequal expansion and contraction where a deep cylinder-head is used, with long bolts passing through it, are avoided.

The cranks and eccentrics are entirely inclosed in sheet-steel oil-guards, and all moving parts are arranged for continuous oiling. The oil-guards are easily removed to permit inspection.

The frame, Figs. 4 and 5, is made of one piece and is of regular Corliss heavy-duty pattern, the guides being bored from a common center. The bottom box of the main journal is of the shell type and can be rolled out of the bed when the shaft is raised slightly. This box is arranged for water circulation on the larger sizes. Wear is taken up by wedge adjustments. There is an extension of the frame around the crank to form the crank-pit and a receptacle from which oil can be drained, and there is an oil-lip around the entire base to catch waste oil.

The plan view of the frame, Fig. 5, gives a good idea of the broad base and the rigidity of the casting. There is a partition between the end of the crosshead guide and cylinder, which separates the oil and water from the piston-rod stuffing-box, and the frame is tapped so that water and oil may be drawn off separately. The frame casting is machined at one setting in a special machine to insure alinement.

The governor is of the centrifugal type, composed of two weights and opposing springs; the center of rotation and the center of gravity being the same, no counterweights are needed. The outward movement of the weights throws the eccentric across and slightly around the shaft, changing the cut-off to suit the load. The spring adjustment is so arranged that almost any degree of sensitiveness can be obtained for parallel operation, and the speed can also be regulated by changing the tension of the springs or adding to the weights.

The exhaust valves are driven from a separate eccentric by which the compres-

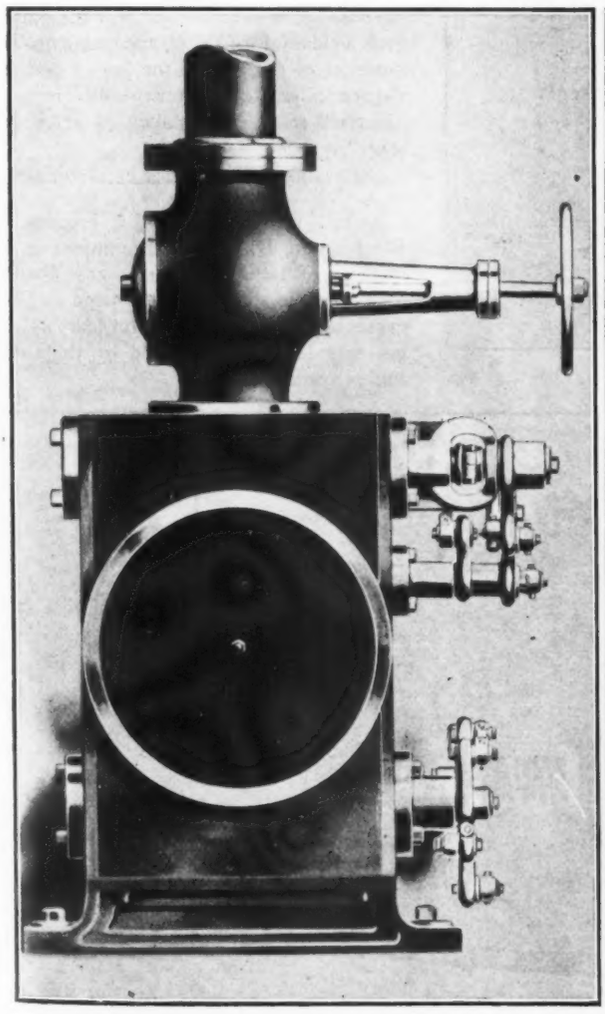


FIG. 4. END VIEW OF CYLINDER

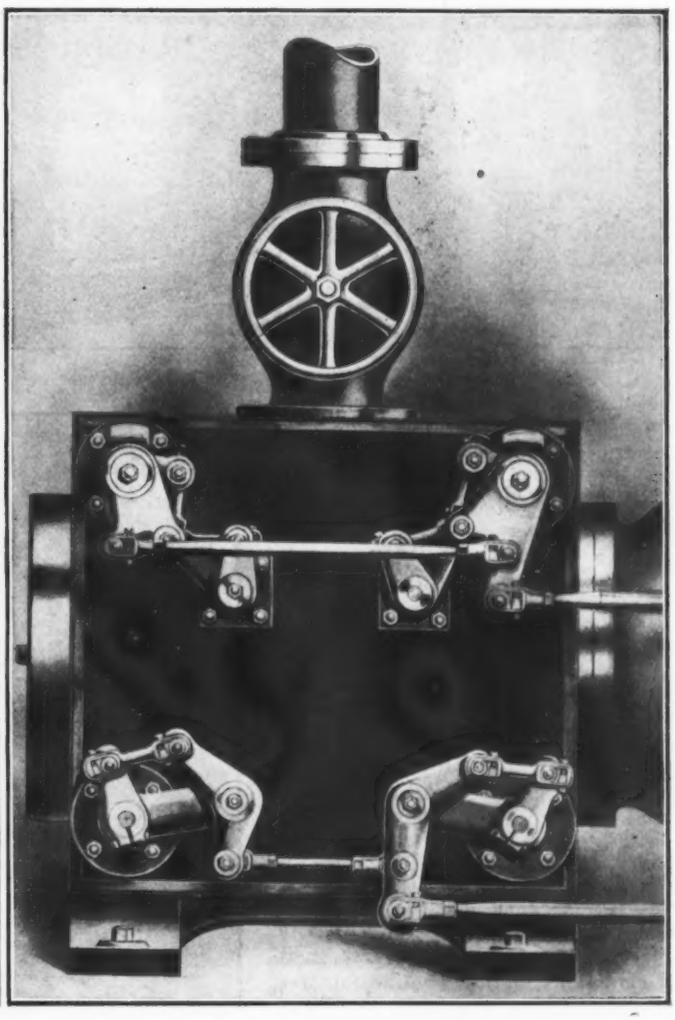


FIG. 5. VALVE-GEAR SIDE OF CYLINDER

sion can be set to properly balance the parts for any required speed.

While the company does not claim that this type of engine is as economical as its regular Corliss releasing-gear type, owing to its shorter strokes and increased clearances, it is believed to be as efficient as it is possible to make a four-valve engine adapted to these high rotative speeds

The works of the Hooven, Owens, Rentschler Company are located at Hamilton, Ohio.

The Hewes & Phillips Condenser

The Hewes & Phillips Iron Works of Newark, N. J., recently put upon the market the independently driven condenser shown in the accompanying engravings. The main shaft, furnished with an ample fly-wheel, and balanced disk-cranks, is operated by a Corliss cylinder and drives the pump plunger, as shown in Fig. 2, through a series of levers, the crank-pin of the pump being at 90 degrees from that of the engine. The connection between the pump-actuating lever and its driving pin is made as shown in Fig. 3, so that the pump will be at mid-stroke when the crank-pin is at its period of greatest movement, and will be passing its centers and reversing the motion of the piston and cylinder contents when the crank-pin is passing its center, and while the movement is consequently very slow.

The pump shaft operates the plunger in the manner obvious from the engraving. The plunger is of bronze, fitted with hard rubber valves held by bronze studs and check-nuts, affording a liberal area for the passing of water and air. The pump barrel is bushed with bronze of a thickness which will stand re-boring. The upper or overflow valves are in a disk of solid bronze of the same area and general construction as those in the plunger. This disk is held in place by studs passing from the principal pump heads to the disk flanges and locked in position by check-nuts, as seen in Fig. 2. This construction permits easy access to the lower as well as to the upper valve. Two large manholes are provided at the level of the outlet valve. The connection to the air pump is of the box pattern, tying the base of the box and the shaft bearing firmly together. A tie-rod extends, as shown in Fig. 2, from the upper to the main bearing, increasing the rigidity of the construction. The air pump and frame are held to the base plate by the usual anchor bolts, and in addition the air pump is held above the joint with independent anchor bolts.

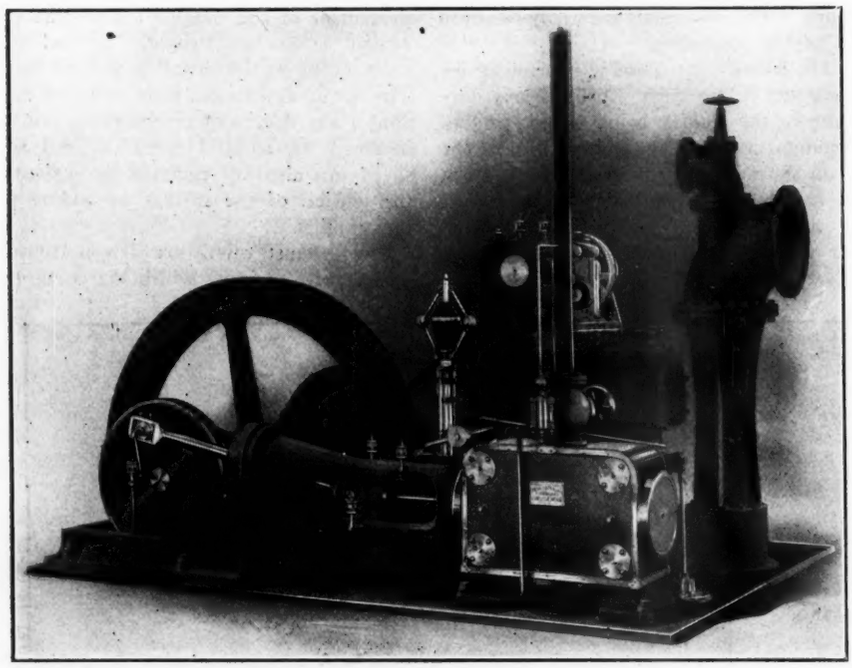


FIG. 1. ENGINE SIDE OF CONDENSER OUTFIT

The condenser proper is constructed upon the Venturi tube principle, the condensate and injection water, together with the entrained air, being driven through the contracted neck at high velocity. The cone is of such design that the injection water may be thrown in in any sized spray desirable, and in the event of foreign substances passing the foot-valve screen, the spray orifice may be cleaned by the manipulation of a hand-wheel shown in the inlet elbow. The same hand-wheel is used to regulate the spray.

A vacuum of 26½ inches can be maintained under ordinary conditions with the air pump alone. The higher vacua desirable for turbine work can be obtained at a little extra cost and complication by the addition of a dry-air pump, as shown in Figs. 3, 4 and 5, the dry-air pump being operated by an extension in the opposite direction to the arm which operates the main plunger. A greater length to this arm gives the dry-air pump a greater stroke, reducing the diameter required and placing it far enough from the other cylinder to preserve accessibility. The connection to this pump is shown plainly in Fig. 3, enough water being admitted at the elbow, as indicated, to seal the valves, and incidentally to cool and condense the contents of the pipe to the lowest possible degree. The condenser in this form is referred to by the maker as its "two-stage" type.

A bill providing for the erection at Washington, D. C., of a monument to the memory of John Ericsson, to cost $50,000, including the site, was introduced in Congress by Representative McCleary. The bill was favorably reported by the Committee on Library.

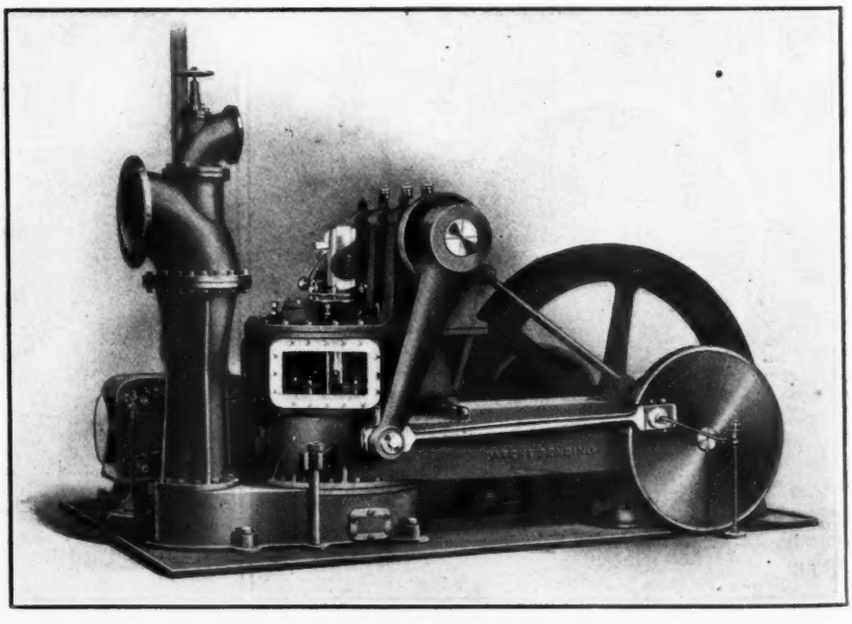


FIG. 2. PUMP SIDE OF CONDENSER OUTFIT

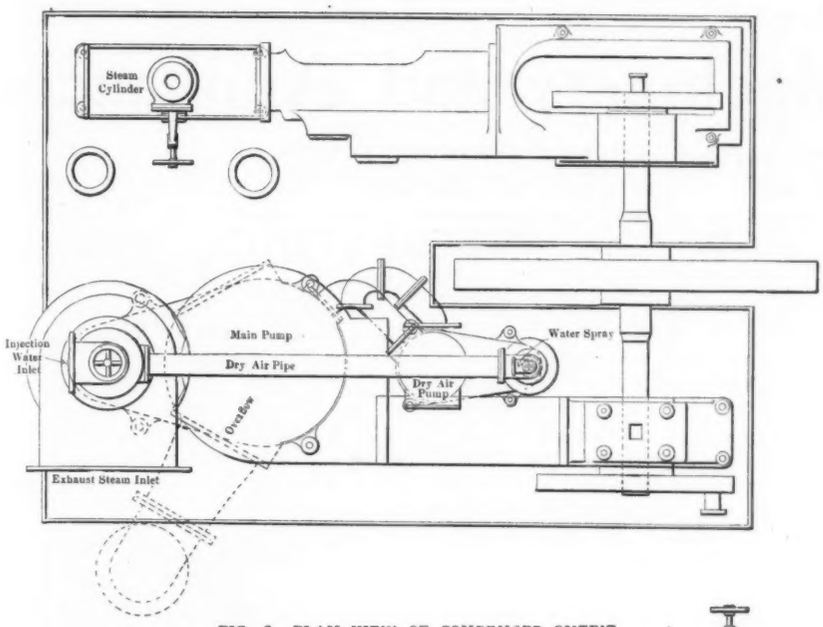


FIG. 3. PLAN VIEW OF CONDENSER OUTFIT

A Smokeless Steam Boiler

BY ROBERT GRIMSHAW

From St. Petersburg comes the announcement of a smokeless steam boiler, invented by a Russian marine engineer with the very un-Russian name of Schmidt. This is a combination of a naphtha-gas motor and an ordinary steam boiler. To set the system going, compressed air is forced into the boiler; this atomizes the naphtha and the water; the two are burned together and water is deposited. The mixture of steam and gas acts directly on the engine. There is no water in the boiler except what is automatically drawn in as required, to be at once vaporized.

The invention was tried at Krayton Works in Ochta before invited specialists, when the boiler was mounted in a torpedo boat placed at the disposal of the inventor by the former marine minister, M. Birilew. The old boiler was four feet in diameter and the engine of 250 horsepower capacity. The Schmidt boiler is only about a quarter the diameter of this and needs no stack. It works automatically, so that the number of stokers is reduced to a minimum, and the work of tending it is naturally much less than with the ordinary boiler.

Details of the test as well as of the construction and operation of this boiler have not yet been made public.

The old main engine by which a certain Lancashire cotton mill was driven before conversion to electrical driving was of 1000 horse-power and was originally installed in 1834, but at a later date was compounded. It was of the beam type, with cast-iron spur fly-wheel meshing with wood-toothed pinions, and with its pumps occupied a floor space of approximately 1040 square feet. Its weight was about 100 tons, it ran at 23½ revolutions per minute, and required an engine room of at least 38,500 cubic feet. The new equipment consists of a 1000-kilowatt three-phase alternator, driven by a steam turbine, which, although capable of greater output than the engine it has displaced, covers only 960 square feet of floor space, weighs 20 tons, runs at 1500 revolutions per minute, and requires an engine room of only 24,000 cubic feet, including the alternator and the switchboard.—*The Engineer* (London).

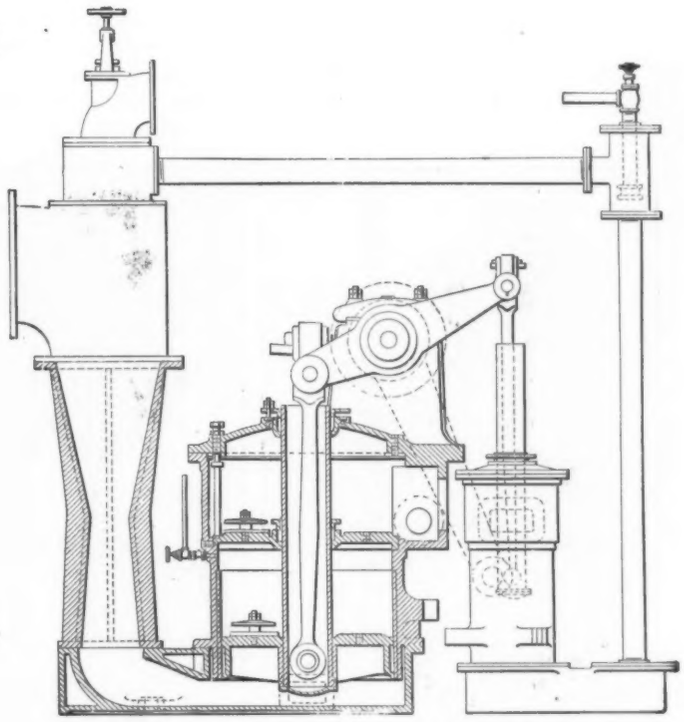


FIG. 5. SECTIONAL ELEVATION OF THE AIR PUMP

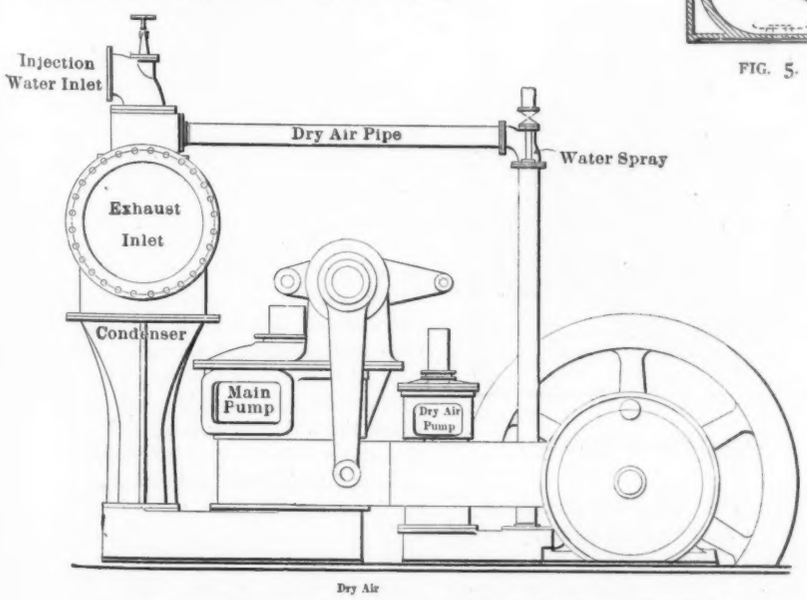


FIG. 4. ELEVATION OF AIR PUMP AND CONDENSING APPARATUS

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

A New Design of Governor

The object of this invention is to provide simple yet efficient means for varying the centripetal force of the governor by increasing the number of springs which may be actuated for high speed and decreasing the number of "low-speed" springs, instead of changing the tension of springs mounted fixedly. Bringing extra springs into position, or withdrawing them from action, affords a wide range of adjustment, which in the case of traction engines is made by means of a lever. The main springs revolve with the weights, or balls, thus avoiding friction that would be set up if the springs were mounted upon the non-rotating parts of the governor.

There is a sliding spring-holder containing a double set of leaf springs of regularly varying and overlapping lengths. When the spring-holder is slid to the adjustment shown in Fig. 1, only the tips of the longest leaves offer material resistance to the spread of the balls. When adjusted as shown in Fig. 2, the tips of the springs pass by the bearings on the ball pins and become idle, while the base portions of the springs, which are five leaves thick, are in position to offer resistance to the spread of the balls. The spring-holder can be held in any position between the two extremes. A reach-rod connects the spring-holder to the actuating lever. The automatic movement is not imparted to any of the parts by which adjustment is made.

The inventor of the governor is Leslie J. Watson, of Upton Works, Mich.

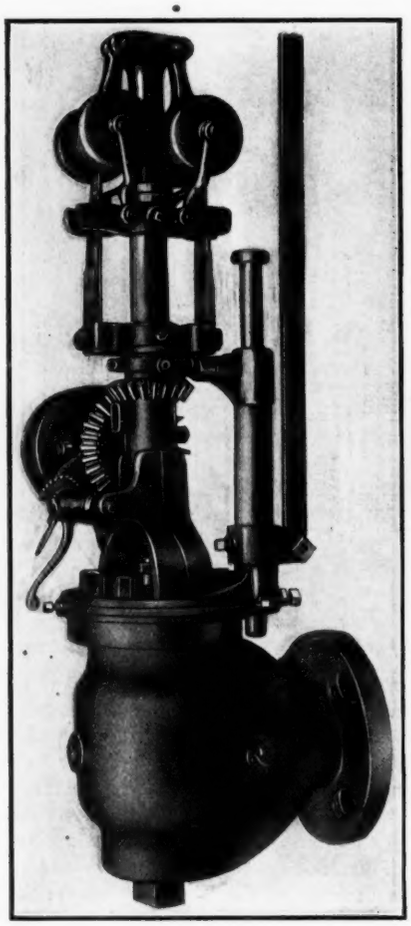


FIG. 1. ADJUSTED FOR SLOW SPEED

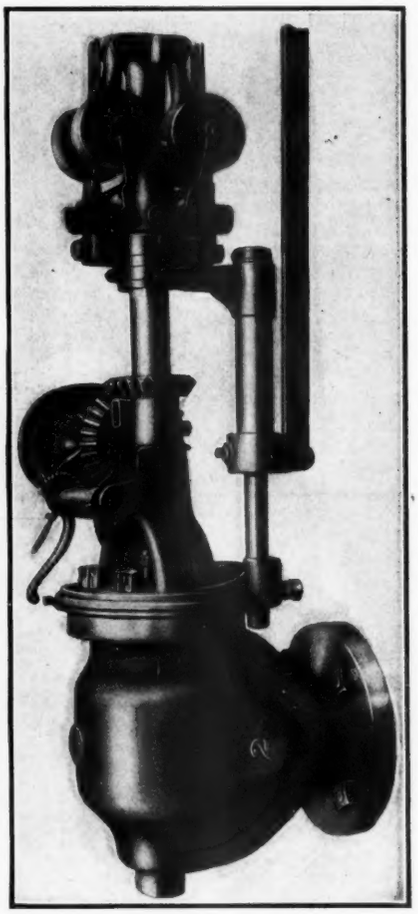
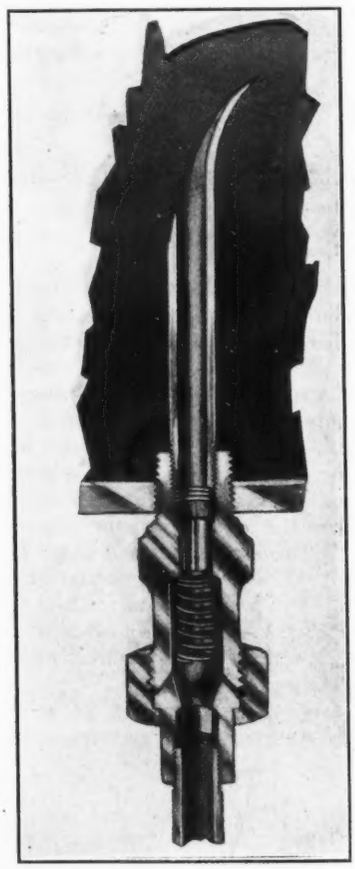


FIG. 2. ADJUSTED FOR HIGH SPEED

Check-valve for "Richardson" Oil Pump

The accompanying half-tone shows in section one of the so-called No. 40 check-valves furnished with the "Richardson" oil pump as used for general steam, air-compressor or dry-vacuum pump service, there being one check-valve for each feed. These valves are provided with union connections, as shown, and have large balls and substantial springs. The small quill shown is used when the check is inserted in a steam pipe, but is omitted when the valve is screwed directly into the steam chest or cylinder casting, a male end being provided. For gas-engine service a special check-valve is required.



CHECK-VALVE FOR RICHARDSON AUTOMATIC SIGHT-FEED OIL PUMP

As is or should be well known to POWER readers, the "Richardson" oil pump is made by the Sight Feed Oil Pump Company, Milwaukee, Wis.

The "Rapid" Tube Cleaner and Coupling

Reproduced herewith is a sectional drawing (Fig. 1) of one one form of the "Rapid" turbine tube cleaner, manufactured by the Thomas Andrews Manufacturing Company, of Rockaway, N. J. This cleaner is designed for use in all types of water-tube boilers, special designs being furnished for special conditions, is made for either straight or curved tubes, and may be operated by water, steam or air pressure. It is simple in construction, parts may be readily replaced, and the only stipulation by the maker is that it shall be well lubricated.

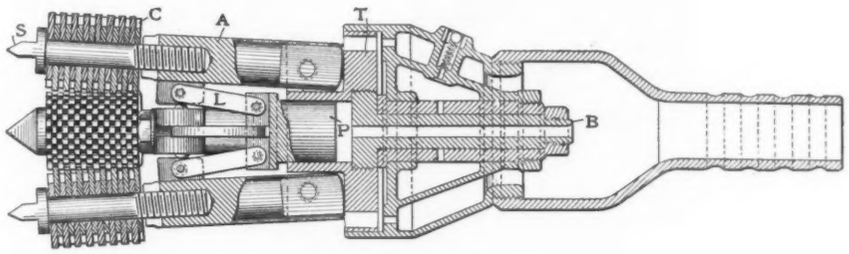


FIG. 1. SECTIONAL VIEW OF "RAPID" TURBINE TUBE CLEANER

The same pressure that revolves the turbine *T* acts on a piston *P*, through a hollow bushing *B* (which is screwed into the turbine and keyed), and forces out the arms *A* against the tubes, the arms and piston being connected by links *L*. The cutters *C* are held in place by hardened tool-steel studs *S*, and the links are adjusted so that the cutters will not spread beyond the inside diameter of the tube. By removing the nut at the end of the bushing *B* the cleaner can be taken apart to clean.

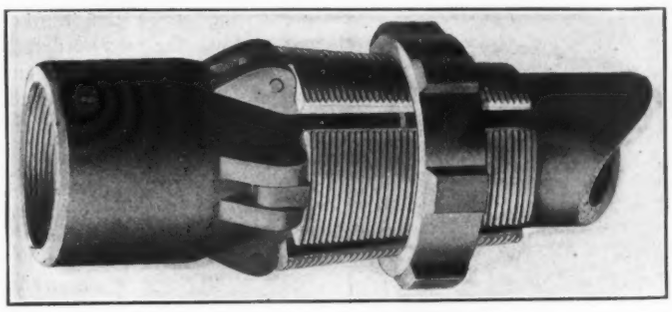


FIG. 2. THE "RAPID" COUPLING

Fig. 2 shows a special style of hose connection designed for use with the "Rapid" cleaner. As will be seen, this coupling can be made to fit any size of hose by simply manipulating the clamping system shown. This consists of four tapered, threaded segmental sections encompassed by a ring clamp correspondingly threaded. The clamp parts are made of springy metal that will not break under uneven strain.

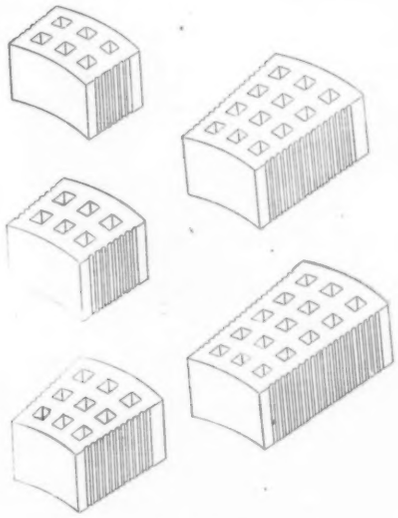
New Combination Flax and Rubber Packing

The Garlock Packing Company, of Palmyra, N. Y., was recently granted a patent for a new form of packing, a section of which is illustrated herewith, composed of high-grade flax vulcanized to a rubber cushion, the adhesion being so firm that it is almost impossible to tear the ingredients apart. This packing is recommended for cold-water hydraulic rods or for elevator plungers. Similar forms of packing have been on the market, but as the flax was only cemented to the rubber it naturally was not as durable as the new packing promises to be.

COMBINATION FLAX AND RUBBER PACKING

Corrugated Radial Brick

The corrugated radial brick shown in the accompanying engravings is used by the M. W. Kellogg Company, 143 Liberty street, New York, in the building of chimneys. The idea involved is that the corrugations upon the heating surfaces of the brick hold the cement or mortar and insure a firm and reliable joint. Tests made by Prof. Mansfield Merriam, of Lehigh University, show that the adhesion between mortar and the corrugated brick is 62½ per cent. greater than between mortar and ordinary smooth brick of the same material. While it may be possible to secure a firm joint between mortar and a smooth hard surface, the process requires some degree of care, with the result that there is a wide variation in the value of the surfaces thus prepared. Professor Merriam's tests show a variation in adhesion of plane joints of 340 per cent., against 29 8/10 per cent. in the joint made with the corrugated surface.



CORRUGATED RADIAL BRICK

The Park Water-tube Boiler

Simplicity and compactness are features of the Park water-tube boiler which strike the casual observer forcibly. It consists of a bank of tubes, two headers, one steam drum and a mud-drum. The cross-drum design has been adopted in order to obtain maximum heating surface with small floor area, and because comparatively little head room is required. It is a practically all-steel boiler, only the headers being of iron ordinarily. No stay-bolts are used and the only riveting is in the steam drum.

Following out the unit-construction idea, in place of an ordinary header a number of sinuous manifolds (Fig. 2) are employed, of such formation that when assembled they nest closely, presenting a dovetailed appearance. Each of these manifolds or headers is in one piece and each hand-hole cover seat is reinforced on the inside. To provide for tube expansion and contraction the front headers are each suspended independently from a

wrought-steel frame, the rear headers being supported as indicated in Fig. 1.

The "four-way" hand-hole cover (Figs. 2 and 3) is peculiar to this boiler and

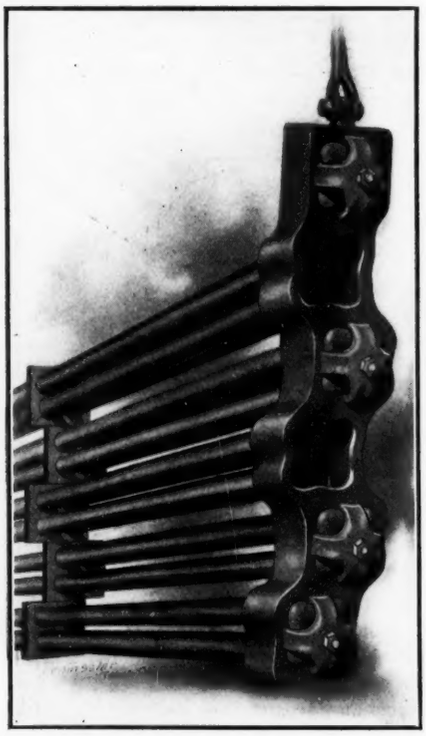


FIG. 2. THE PARK HEADER

gives access to four tubes at once. It is an inside cap, of drop-forged steel, and is used with a gasket. The caps and gaskets are interchangeable, of course. The stress due to steam pressure is obviously borne by the caps, and not by the bolts.

It will be seen by further study of Fig. 2 that the tubes connected to each header are in groups and the groups are staggered so as to deflect the gases over and around each tube. A 3-inch tube is used, partly to promote rapid steaming and to obtain greater heating surface. Vertical baffles (Fig. 1) are so arranged that the hot gases pass up, down and up again through and practically at right angles to all the tubes.

Attention is directed also to the Park baffle-brick (see Fig. 3), which is a four-way, one-piece baffle made of an iron pan cast in the required shape and packed with fire-clay. Lugs cast in the metal part become imbedded in the clay, thus binding the latter and its shell firmly together. It is pointed out, and it is quite conceivable, that this baffle cannot slip out of place and fall among the tubes, and it is practically indestructible.

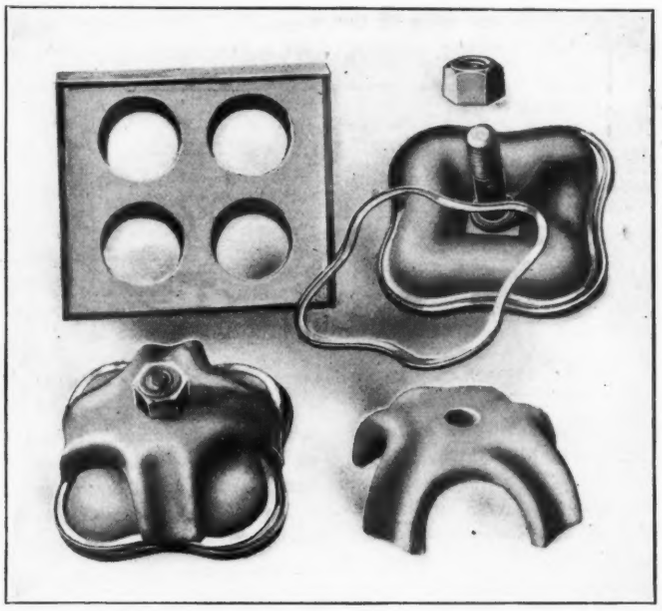


FIG. 3. BAFFLE-BRICK AND DETAILS OF PARK HEADER-CAP

Regarding the circulation in the Park boiler, its course is apparent from Fig. 1. Each header is connected to the steam drum by four delivery tubes. A perforated baffle in the drum directs the current of water downward and to the rear tubes, the steam meanwhile rising through the perforations in the baffle-plate. Running the full length of the steam drum is a feed-pan which first receives the feed-water. Being constantly surrounded by live steam and the hottest water in the boiler, the temperature of the feed is raised appreciably at the outset, releasing many impurities before the water reaches the headers. The feed-water overflows evenly the entire length of the drum, passes down the rear headers, through the tubes to the front headers, and up to the steam drum. The mud-drum is located directly under the rear headers, as shown in Fig. 1.

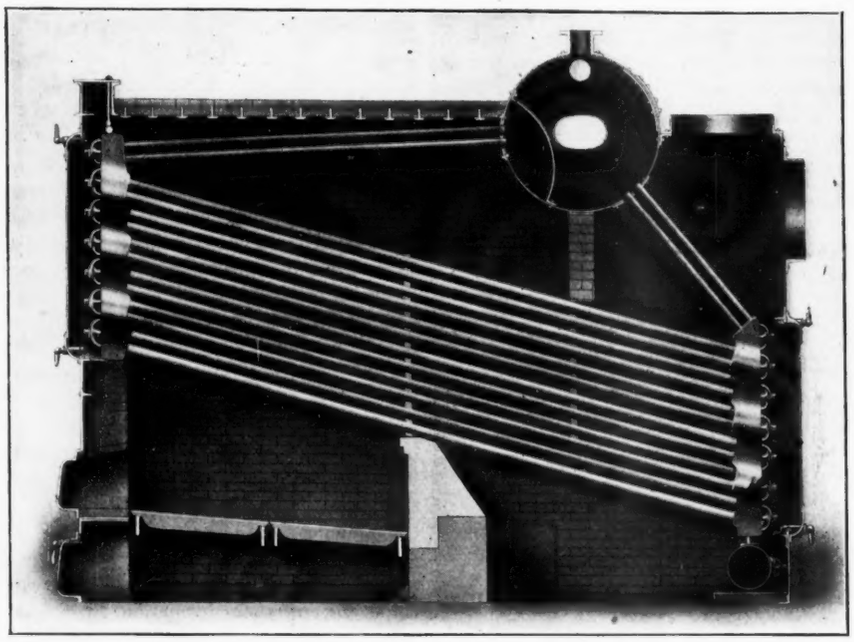


FIG. 1. SECTIONAL VIEW OF PARK WATER-TUBE BOILER

The steam drum is provided with a man-hole for cleaning out and the feed-pan can be removed through the opening; the tubes are cleaned by removing the front header-caps and pushing the sediment back into the rear headers, when it can be removed through the bottom hand-hole or later blown out of the mud-drum. All work can be done from the outside.

This boiler is manufactured by the D. D. Flanner Boiler Company, Toledo, Ohio.

It is stated that the best results are obtained with air compressors when the areas of the suction and discharge valves are equal and of such proportions that the velocity of the air does not exceed 5500 feet per minute.

The "Standard" Force-feed Lubricator

In this lubricator all the working parts except the driving clutch are within the body of the device, where they operate

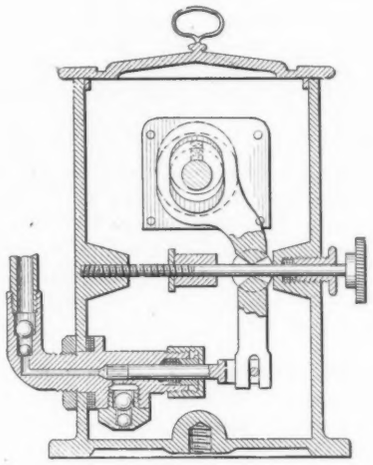


FIG. 1

in the oil, therefore being well lubricated and at the same time protected from grit and dust. The driving clutch is mounted on the main shaft, which is fitted with a stuffing-box. See Fig. 2. The actuating principle of the driving clutch, which is of the roller-bearing type, is clearly shown in Fig. 3. There are three hardened-steel rollers, each ½ inch long, working between curved eccentric surfaces. A pin, actuated by a spring, keeps each little roller pressed forward into the narrowing end of the bearing channel, in close contact with the shaft, so that the clutch movement is bound to be positive and the response instantaneous and reliable.

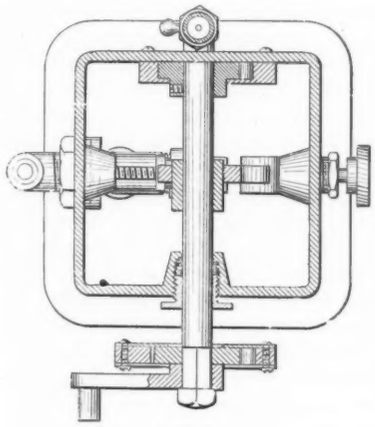


FIG. 2

An eccentric cam on the main shaft oscillates a hinged lever which actuates the feed-pump plunger, as shown in Fig. 1. The play of the lever is limited by means of a collar mounted on an adjusting screw, which is manipulated by means of a thumb-screw head. The stem of the adjusting screw passes through a stuffing-box in the side of the lubricator. A hand crank is provided, whereby the lubricator can be operated as a hand-pump.

The feed-pump is of the packed-plunger type, with double inlet and outlet valves, as shown in Fig. 1, and where more than one feed is used each pump is independent and can be adjusted to deliver any number of oil drops per minute, up to its maximum capacity, without interfering with the action of any other pump.

These lubricators are rectangular, with

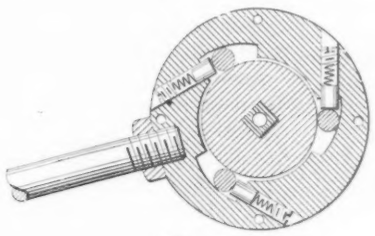
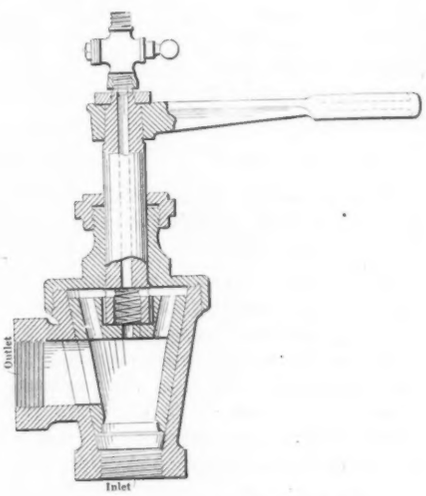


FIG. 3

round corners, and each is equipped with a gage glass. They are regularly built in one-pint, one-quart, two-quart, one-gallon and two-gallon sizes, with from one to four feeds. More feeds can be provided, if desired. The maker is the Standard Force Feed Lubricator Company, of Rochester, N. Y.

The "Peerless" Balanced Blow-off Valve

Herewith is a sectional view of the "Peerless" balanced blow-off valve, de-



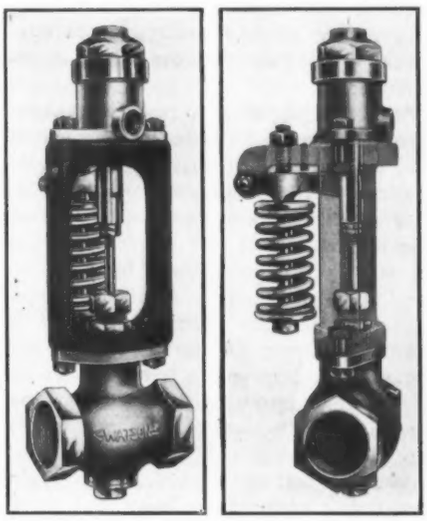
THE "PEERLESS" BALANCED VALVE

signed by Robert Rice, a Detroit engineer. It will be noted that the inlet is at the bottom and the delivery port at the side. Between the perforated top of the tapered plug and the bonnet is a steam space, and when the pressure is applied the plug is balanced. The inlet being through the center of the plug at the bottom, grit and sediment carried in the steam and water do not come into contact with the ground surface of the plug, consequently the claim is made that it will not leak, and the valve does not require packing. The joint at the bonnet and jacket is intended to be so true that there is no possible outlet except through the port. It is further stated that a 12-inch wrench will open or close the valve under pressure as easily as when "dead."

The "Peerless" is made by the American Tap-Bush Company, Detroit, Mich.

Watson Steam-pump Governor

The accompanying illustration shows the essential features of the Watson steam-pump governor which is manufactured by the Watson & McDaniel Company, of Philadelphia, Penn. The purpose of this device is to maintain automatically a fixed discharge pressure and to limit the supply of steam so that the



THE WATSON STEAM-PUMP GOVERNOR

pump will not run away in case of accident.

The spring, instead of being located on the valve-stem, is placed at one side of the valve and bears on a lever which in turn imparts the tension to the stem. It is obvious that the spring has to move through a distance equal only to part of the travel of the valve, about one-third, and maintains a nearly even tension in consequence, resulting in equally uniform regulation.

As will be seen, this construction permits easy access to the stuffing-box, and the spring can be adjusted or removed without interfering with any other part of the valve.

These governors are made either in straight pattern or with angle bodies, in sizes ranging from ¾ inch to 1½ inches for brass valves with screwed ends, and from 2 to 4 inches for iron bodies with flanged ends.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Can Exhaust Steam be Used in Refrigerating Coils?

The company by which I am employed is using a 10x15-inch engine to pull a 7x12-inch ammonia compressor for a five-ton ice plant. We are using 24 lengths of 16-foot by 2-inch pipe for steam coils, 12 pipes in each coil, steam at 60 pounds, the valve at coils open but very little. I would like to know if it is possible or practicable to use engine exhaust for steam in the coils? What size receiver would be required? Mention a suitable oil separator, and state what would be the back pressure on the engine. J. E. S.

West Point, Ga.

While exhaust steam is used in all ice-making plants of the larger sizes, we have our doubts as to whether there would be material saving by its use in a plant of only five tons daily capacity, as the extra trouble and expense connected with removing the oil from the condensed water would go far to offset the saving in coal effected.

Should you wish to use the exhaust steam, it should be passed first though an oil separator, which may be a horizontal cylinder partially filled with water on the surface of which the steam would impinge before passing to the condenser. The water level is maintained by a water-sealed overflow pipe. After being condensed, the water must be re-boiled in order to drive off foreign gases, and skimmed to remove the last traces of oil. The former operation is affected by live steam from the boiler and the latter by an overflow pipe set at the surface of the water, so that there is always a slight overflow. From the re-boiler and skimmer the water passes to the storage tank.

Without knowing just how you would connect to the condenser, one cannot say just what the back pressure will be on the engine. The connection should be such that the full area of the exhaust pipe is maintained. As a matter of fact, there would be times when the condenser would not take care of all of the steam and the back-pressure valve on the exhaust pipe would be necessary. In this event you would need no relief valve on the receiver.

Weighting a Rites Governor

Does adding weight to the long arm of a Rites governor make the governor steadier or the reverse? G. W. S.

It makes the governor steadier and therefore less sensitive, because a greater change of speed is necessary to overcome the inertia of the greater wieght. The engine will not regulate so closely, but it will have less tendency to "hunting."

Temperature of Compressed Air

What will be the temperature of air compressed to 600 pounds per square inch, gage pressure? L. W .S.

If there is no cooling during the compression, the temperature after compression will be that given by the formula:

$$T_2 = T_1 \times \left(\frac{P_2}{P_1}\right)^{0.29}$$

in which

T_2 = Absolute temperature after compression,

T_1 = Absolute temperature before compression,

P_2 = Absolute pressure after compression,

P_1 = Absolute pressure before compression.

You do not state the initial pressure and temperature, but the former is doubtless atmospheric. Assuming an initial temperature of 62 degrees Fahrenheit and atmospheric initial pressure, the value of T_1 will be 62 + 460 = 522 degrees absolute, and the value of P_1 willl be 147; your compression pressure being 600 pounds gage, it will be 614.7 pounds absolute, so that

$$T_2 = 522 \times \left(\frac{614.7}{14.7}\right)^{0.29}$$

614.7 ÷ 14.7 = 41.82, and the logarithm of 41.82 is 1.621384; multiplying this by 0.29 gives 0.4702014 as the logarithm of the 0.29th power of 41.82, and the number of which this is the logarithm is 2.9526.

Therefore,

$$\left(\frac{614.7}{14.7}\right)^{0.29} = 2.9526,$$

and 522 × 2.9526 = 1541.26, which is the absolute temperature after compression. Subtracting 460 from this leaves the thermometric temperature, which is 1081.26 degrees.

Symbols for Gases

What is meant by the small numbers used in chemical symbols for gases; thus, H_2O, CO_2 and C_2H_4? R. G. C.

The numbers indicate the number of atoms of the elementary gas or substance that are contained in one molecule of the compound formed by the elementary gases and substances. Thus, in one molecule of water or steam, H_2O, there are two atoms of hydrogen and one of oxygen; in one molecule of carbon dioxide, CO_2, there are one atom of carbon and two of oxygen; in one molecule of ethylene gas, C_2H_4, there are two atoms of carbon and four of hydrogen. The number of atoms determines the relative weights of the compounds; thus, an atom of carbon has twelve times the weight of an atom of hydrogen, an atom of oxygen has sixteen times the weight of an atom of hydrogen, and so on. One molecule of water, therefore, has eighteen times the weight of an atom of hydrogen.

Mean Effective Pressure of a Gas Engine

Why cannot the mean effective pressure and horse-power of a gas engine be calculated without taking an indicator diagram, as is done in the case of a steam engine? G. E. L.

Because there is no means of predetermining the quantity of heat taken out by the water jacket, and also because it is impossible to predict the rapidity of combustion of the mixture in the cylinder. If it were possible to operate with as small a heat loss, relatively, as in a steam engine and to obtain the same rate of flame propagation every time, the mean effective pressure could be calculated with as near an approach to accuracy as in the case of the steam engine. As a matter of fact, it is impossible to calculate with absolute accuracy the output of a steam engine unless one has an indicator diagram.

Duplex Pump Capacity

How can I figure the amount of water that a duplex pump will deliver per hour at a known speed? G. W. E.

Multiply the piston area by the stroke in inches; this gives the displacement in cubic inches per stroke. Multiply this by the number of strokes per hour, and the result will be cubic inches per hour per cylinder; multiply this by 2 (there being two cylinders) and divide by 231 and the result will be the theoretical number of gallons per hour delivered by the pump. Owing to slippage, however, it is usual to figure on about 80 per cent. of the theoretical delivery. If you wish to get the result in pounds instead of gallons, multiply the cubic inches by 0.036 instead of dividing by 231.

Gas-engine Valves

(*a*) Which is more efficient, automatic or mechanically opened inlet valves for a gas or oil engine, and why? (*b*) What is the proper relation between valve opening and cylinder dimensions? K. G. Y.

(*a*) Mechanically operated valves give the engine more power because they are held wide open the maximum allowable length of time and therefore enable the piston to draw in the maximum possible charge. (*b*) It depends on the piston speed as well as its displacement. The inlet-valve opening should be such that the speed of the incoming charge will not exceed 6000 feet per minute; the exhaust-valve opening should give a speed of not more than 5000 feet per minute to the exhaust gases. Even better values are 5000 feet for intake and 4000 feet for exhaust.

Compound-engine Cylinder Ratio

What is the rule for the cylinder ratio of a compound engine to divide the work equally between the two cylinders? J. T.

Make the cylinder ratio =

$\sqrt{\text{Number of expansions}}$

British Columbia Association of Stationary Engineers

The fourth annual convention of the British Columbia Association of Stationary Engineers (Grand Lodge) was held at Vancouver, B. C., July 11 and 12. There were several sessions and considerable important business was transacted. A visit was made to the generating station of the British Columbia Electric Railway Company, at Lake Buntzen, by special invitation of the company.

The convention came to a happy conclusion with a banquet, which was attended by one hundred and fifty persons. The opening address by Chairman L. Fox, of Vancouver Lodge, was warmly received. A toast to "The Guests," by W. H. Paddon, evoked a pleasing response from J. Manson. R. D. Sprague, grand secretary, delivered an eloquent address on the great work the association has accomplished. His remarks were responded to by W. J. Bowser, M. L. A. Many other interesting addresses were made. Vocal and instrumental numbers by engineers and guests added to the enjoyment.

The selection of officers for the ensuing year resulted as follows: Arthur Manson, grand chief; Thomas Brown, grand vice-chief; R. D. Sprague, grand secretary; L. Fox, grand treasurer; F. N. Jones, grand door-guard.

Convention of Universal Craftsmen Council of Engineers

The fifth annual convention of the Universal Craftsmen Council of Engineers, was held on the 17th floor of Masonic Temple, Chicago, August 6 to 10, inclusive. Commandery Hall, which adjoins the room in which the business sessions were held, was utilized for exhibits, there being 40 booths.

The convention was the largest and most successful ever held by the organization. The flourishing condition of the society was shown by the report of the retiring grand chief, Robert G. Ingleson, of Cleveland. Part of the surplus in the grand treasurer's hands will be returned to subordinate councils, of which twenty were represented at the convention. Chicago Council, No. 1, with more than 400 members, and which at its meeting of August 10 initiated 40 members, was declared the banner council.

It was decided that hereafter all the expense of annual meetings be paid out of the funds of the grand council, and exhibits by manufacturers will not be invited. As no one is eligible to membership who is not an engineer and a master Mason, it was deemed advisable to adopt this policy in order to insure absolute independence of action and freedom from possible outside influence.

Visiting delegates and friends expressed themselves highly pleased with the entertainment features provided by the local committee, of which Sim. J. Stevenson was chairman, Alfred Johnson, treasurer, and F. Elmo Simpson, secretary. The crowning social event was a banquet at King's Parlors Friday night, attended by 225 persons.

The following officers were elected for the ensuing year: Grand worthy chief, John L. O'Brien, Chicago; grand assistant chief, John J. Chisholm, New York; past chief, Robert G. Ingleson, Cleveland; grand secretary, W. J. Ranton, Rochester; grand treasurer, J. W. Gilbert, Buffalo; grand warden, A. K. Young, Pittsburg; grand guard, W. H. Bridenbaugh, Toledo; grand chaplain, John Cope, Cleveland; grand trustees, B. Dettleback, Cleveland; W. S. Smith, Baltimore; Walter Prior, Newark, N. J.

The 1908 meeting will be held at Put-in-Bay, Ohio.

Canadian Stationary Engineers' Convention

The eighteenth annual meeting of the Canadian Association of Stationary Engineers was held in City Hall, Guelph, Can., August 13, 14 and 15. The convention was opened by Mayor John Newstead, who presented the delegates and guests the freedom of the city. The response was by President George E. Bennett.

There were enjoyable visits to Riverside park, the Ontario Agricultural College, and to various power plants. A banquet at King Edward Hotel concluded the meeting, which was unanimously considered the most successful in every way of any convention held by the society.

Personal

L. B. Lent, now representing the Riverside Engine Company, of Oil City, Penn., has charge of the company's New York office at 26 Cortlandt street, New York City.

Walter G. Stephan has resigned from the Wellman-Seaver-Morgan Company and opened an office in the Citizens' building, Cleveland, Ohio, where he will conduct his profession of mechanical engineer. He will make a specialty of power plants of all descriptions.

Frank Richards, author of "Compressed Air," and who was for ten years associated with the editorial department of the *American Machinist*, has become managing editor of *Compressed Air*, which recently was transferred by the Kobbé Company to the Compressed Air Magazine Company, with headquarters at 11 Broadway, New York. Lucius T. Wightman is business manager of the magazine, *vice* P. F. Kobbé, Jr.

H. C. Hale, manager of the Mineral Ridge (O.) Manufacturing Company, and F. B. Duncan, manager of the Akron (O.) Electrical Manufacturing Company, have resigned their positions to form a partnership, under the firm name of Hale & Duncan, for the conduct of contracting and designing engineering. They will give especial attention to the electrical equipment of mines. Their headquarters will be at Cleveland, Ohio.

Obituary

P. H. Glatfeller, president of the York Manufacturing Company, of York, Penn., died July 11 at Spring Forge, Penn.

Homer Parmelee, of Chicago, a well-known inventor, died August 12 in his eighty-ninth year. Mr. Parmelee invented a large number of machines and devices for boiler-shop use, of which his last, the Parmelee pipe-wrench, was placed on the market about eight years ago.

Lunkenheimer Employees' Picnic

This year's picnic of the employees of the Lunkenheimer Company, of Cincinnati, was held July 27 at Whitewater park, about 25 miles from the city. Nearly 5000 persons were present, going in three special trains of 15 cars each, and all pronounced it the "best picnic ever." Dancing, vaudeville, band concerts and refreshments were provided free by the company, and prizes were awarded the winners of games.

A Correction

In equation (40) on page 622 there is a typographical error, noticed too late for correction there. The formula should have been printed

$$W = P_a V_a \left[\frac{\left(r_c^{n-1} + \frac{319\, h\, u}{P_a (1+a)\ (1+c)} \right) \left(1 - \frac{1}{r_c^{n-1}} \right)}{n_e - 1} - \frac{r_c^{n-1} - 1}{n_e - 1} \right] \qquad (40)$$

instead of the way it appears on the page mentioned. The error is in the use of the plus sign instead of the minus sign in the expression

$$\left(1 - \frac{1}{r_c^{n-1}} \right).$$

Engineering Societies

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President, Frederick W. Hutton, New York, N. Y.; sec., Calvin W. Rice; house, 29 West 39th St., New York. Next meeting, New York, December, 1907.

ENGINEERS' CLUB OF PHILADELPHIA

Pres., Henry H. Quimby; sec., Walter L. Webb; house, 1122 Girard St.; regular meetings 1st and 3d Saturdays.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Navy Dept., Washington, D. C. Pres., B. C. Bryan, Commander, U. S. N.; sec. and treas., Theo. C. Fenton, Commander, U. S. N.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., M. F. Cole, Newman, Ga.; sec., J. D. Farasey, Cleveland, O. Next meeting, Atlanta, Ga., fall of 1907.

WESTERN SOCIETY OF ENGINEERS

Pres., W. L. Abbott; sec., J. H. Warder, 1737 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Julian Kennedy; sec., F. V. McMullin, Pittsburg, Pa. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Arthur Williams, New York; sec. and treas., W. C. L. Eglin, Philadelphia. Association headquarters, 136 Liberty St., New York.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dr. Samuel Sheldon; sec., Ralph W. Pope, 95 Liberty St., New York. Meetings monthly excepting July and August.

ENGINE BUILDERS' ASSOCIATION OF THE UNITED STATES

Pres., A. L. Merriam, Oswego, N. Y.; sec., C. H. Sembower, Reading, Pa.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John L. O'Brien, Chicago, Ill.; sec., W. J. Ranton, Rochester, N. Y. Next meeting, Put-in-Bay, Ohio, August, 1908.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., T. N. Kelsey, Lowell, Mass.; sec., F. W. Raven, 525 Manhattan Building, Chicago, Ill. Next convention, Niagara Falls, N. Y., September, 1907.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., A. J. Dietrich, Baltimore, Md.; Supr. Cor. Engr., Frederick Markoe, 931 N. Orianna St., Philadelphia, Pa. Next convention, Baltimore, June, 1908.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Pres., Wm. T. Magruder; sec., F. W. Ballard, 104 Canal St., Cleveland, O.

MASTER STEAM BOILER MAKERS' ASSOCIATION

Pres., J. H. Smyth; sec., Geo. M. Clark, 1337 N. Maplewood Ave., Chicago, Ill.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, Peoria, Ill. Next convention, Philadelphia, September, 1908.

New Catalogs

Ingersoll-Rand Company 11 Broadway, New York. Bulletin No. 2010. "Crown" pneumatic hammers. Illustrated, 24 pages, 6x9 inches.

Greene, Tweed & Company, 109 Duane street, New York. Catalog. Rochester automatic lubricators. Illustrated, 71 pages, 6x9 inches.

Sprague Electric Company, 527-531 West Thirty-fourth street, New York. Catalog No. 315. Electric fans. Illustrated, 34 pages, 7x9 inches.

Minneapolis Steel and Machinery Company, Minneapolis, Minn. Brochure No. 101. Twin City Corliss engine. Illustrated, 32 pages, 6x9 inches.

Morehead Manufacturing Company, Detroit, Mich. Catalog. Tilting steam traps, return and non-return. Illustrated, 40 pages, 6x9 inches.

Locke Regulator Company, Salem, Mass. Catalog. Locke automatic engine stop and speed limit system. Illustrated, 32 pages, 6x9 inches.

The U. S. Rapid Fire Gun and Power Company, Derby, Conn. Catalog. Francke four ported engine. Illustrated, 28 pages, 6x9 inches.

Trill Indicator Company, Corry, Penn. Catalog. Steam engine indicators, reducing wheels, planimeters. Illustrated, 31 pages, 6x9 inches.

Revere Rubber Company, 77 Bedford street, Boston, Mass. Catalog. Belting, packings, valves, springs, etc. Illustrated, 131 pages, 6½x9 inches.

The Canton-Hughes Pump Company, Canton, Ohio. Booklet. Steam pumps and hydraulic machinery. Illustrated, 62 pages, 3½x6 inches.

The Barriett Electric Manufacturing Company, Cincinnati, O. Bulletin No. 5. Type E motors and generators. Illustrated, 12 pages, 7½x10 inches.

Ingersoll-Rand Company, 11 Broadway, New York. Booklet 20A. Temple-Ingersoll electric air drill. Illustrated, 19 pages, 3½x5½ inches.

Harbison-Walker Refractories Company, Pittsburg, Penn. Booklet. A Little Talk on Brick for Cupola Linings. Illustrated, 15 pages, 3x6 inches.

Abenaque Machine Works, Westminster Station, Vt. Pamphlet. Gas or gasolene driven compressor outfits. Illustrated, 8 pages, 6x9 inches.

The Westinghouse Machine Company, E. Pittsburg, Penn. Catalog S. Storage batteries for stationary service. Illustrated, 31 pages, 6x9 inches.

Jeffrey Manufacturing Company, Columbus, Ohio. Bulletin No. 12. The Care of Electric Mine Locomotives in Service. Illustrated, 80 pages, 8x10 inches.

Gisholt Machine Company, Madison, Wis. Catalog. Gisholt lathes (American Type), boring mills, tools grinders. Illustrated, 14 pages, 8x10 inches.

The Northern Specialty Co., Inc., 63-65 Columbia street, Utica, N. Y. Circular. Combination water gage and automatic safety valves. Illustrated.

A. O. Norton, 286 Congress street, Boston, Mass. Catalog. Norton ball-bearing and "Sure Drop" track jacks. Illustrated, 36 pages, 3½x6 inches.

American Boiler Economy Company, Mutual Life Building, Philadelphia, Penn. Catalog. Copes regulators. Illustrated, 20 pages, 3½x6 inches.

New Equipment

The Dean Electric Company, Elyria, Ohio, is erecting a new plant.

The Albany (N. Y.) Steam Trap Company will erect a new factory.

Hochschild, Kohn & Company, Baltimore, Md., will erect a power house.

Plans are being prepared for water works for the city of Frankfort, Kan.

The city of Dickson (Tenn.) is considering the construction of water works.

The city of Blacksburg, Va., is considering the construction of water works.

The Ashton Valve Company, Boston, Mass., will erect a new plant to cost $67,000.

The Heine Safety Boiler Company, St. Louis, Mo., will erect a new $300,000 plant.

The Albia (Ia.) Electric Light and Power Company will increase the capacity of its plant.

The city of Beebe, Ark., contemplates establishing an electric-light plant and water works.

The Consumers Electric Light and Power Company, Hazleton, Penn., will build a substation.

Longman & Martinez, paint manufacturers, New York city, will erect a new factory in Brooklyn.

The Independent Light and Power Company, Davenport, Iowa, will erect a new power house.

The Hawks Electric Company, Goshen, Ind., is preparing to erect a new plant to cost $25,000.

The Potomac Electric Power Company, Washington, D. C., will erect an additional power house.

The Kohro Packing Company, Davenport, Iowa, will erect a new boiler house and ice machine house.

The Seattle (Wash.) Electric Company is planning to erect two sub-stations at a cost of $20,000 each.

The electric-light plant of the Willamette Valley Company at Cottage Grove, Ore., was recently destroyed.

The San Antonio (Texas) Gas and Electric Company is contemplating the purchase of a site for a new power plant.

Plans have been prepared by the Pekin (Ill.) Electric Light Company for improvements to cost about $50,000.

The Mahoney City (Pa.) Light, Heat and Power Company is making extensive improvements and additions to its plant.

The citizens of Kings Mountain, N. C., are reported to have voted to issue $50,000 bonds for water works and an electric-light plant.

It is reported that the city of Elyria, O., will vote on issuing $75,000 for the construction of a municipal electric-light plant.

The city council of Fremont, Neb., has decided to construct an entirely new electric-light and water-works station, at a cost of about $65,000.

The Ralston Oil and Grease Company, St. Louis, Mo., has been organized to manufacture oils and greases by Robert C. Ralston, Charles A. Ralston, etc.

C. H. Chandler, of the Chandler Pump Company, Cedar Rapids, Iowa, is interested in a new radiator plant now being erected, which will include a power house.

The Hamilton Manufacturing Company, Lowell, Mass., will erect a new boiler house and coal pocket, which is to be equipped with the latest coal-handling appliances.

The Columbus (Miss.) Railway, Light and Power Company is planning to build several

extensions to its railway system and to remodel the electric-light and gas plants.

The Street Railway and Power Company, Americus, Ga., recently organized, has obtained the necessary franchises. About $150,000 will be spent in electrical equipment.

Business Items

The Gardner Governor and Separator Company, of Quincy, Ill., is sending out a very attractive post card, in colors, on the message side of which is a bird's-eye view of the company's works.

The Chapman Valve Manufacturing Company has combined its storerooms and offices in St. Louis at 16 South Twelfth street. R. C. Page has been appointed manager of the St. Louis branch.

The Sterling Lubricator Company, Rochester, N. Y., has been awarded the contract for installing Sterling lubricators in the power plant of the new building of the Department of Commerce and Labor at Washington, D. C.

The Northern Engineering Works, crane builder, Detroit, Mich., has installed one 20-ton power-station crane for the Toledo Gas and Electric Company, and two 20-ton cranes in the Murphy power plant at Detroit, Mich.

The American Stoker Company has opened an office in St. Paul, Minn., at 317 and 318 American National Bank building, in charge of John J. Dwyer, also an office at 1207 Park building, Pittsburg Penn., in charge of H. C. Adam.

The United Lubricator Company has been organized at Detroit, Mich., and has opened offices at 28 Buhl building. E. H. Campbell, formerly with the Penberthy Injector Company, has been appointed sales manager of this new company.

The Atlas Engine Works, has appointed Otto Dieckmann, Jr., manager of its direct sales office at St. Louis. Mr. Dieckman, who has been representing the Atlas Works at St. Louis for some time, will continue his offices in the Chemical building.

The H. W. Johns-Manville Company has completed arrangements for the exclusive sale of the Magic boiler compound. The company has issued an interesting folder entitled, "How to Clean a Boiler," which gives some information on this subject.

The town of Little Valley, N. Y., recently closed a contract for a new electric-lighting equipment which includes an Allis-Chalmers 150-kilowatt, 60-cycle, 1100-volt alternator; an 8-kilowatt 120-volt direct-connected exciter and an 18x42-inch Allis-Chalmers Corliss engine of 250-horse-power heavy-duty type.

The Rhodes Improved Metallic Packing Company recently opened an office in the Singer building, 149 Broadway, New York. This company makes a specialty of metallic packing for railroads, floating equipment and stationary plants. The packing is manufactured in the company's own plant in Jersey City.

The Parker Boiler Company, Fifteenth and Chestnut streets, Philadelphia, has received orders for the Parker boiler from the following: Austin Manufacturing Company, Harvey, Ill., one 365-horse-power; Southern Indiana Hospital for Insane, Evansville, Ind., three 300-horse-power; Perth Amboy Chemical Company, Perth Amboy, N. J., one 267-horse-power.

The Wilpaco Packing Company has been formed to handle and exploit in the United States the hydraulic packing made under the Williamson patent. This packing has been used and tested by a number of the most prominent engineer and industrial concerns in Great Britain. Circulars and other descriptive matter may be obtained from the office at 31 Nassau street, New York.

The Southern Hydraulic Engineering Company, Atlanta, Ga., and Birmingham, Ala., has been appointed agent for the products of C. H. Wheeler Manufacturing Company, of Philadelphia. These consist of the Wheeler-Mullan high-vacuum apparatus, the Wheeler-Pratt water-cooling towers, Wheeler-Barr pumps, C. H. Wheeler feed-water heaters and the Mullan suction valveless air-pumps.

E. H. Kellogg & Co., 243 South street, New York, have received through their Liverpool, England, office a letter from the chief engineer of Joseph Wade & Sons, of Bradford, Yorkshire, in which he says that they have been using "Anti Corrosive" cylinder-oil for a number of years for their surface condensing engines and consider it the best of all the oils they have tried for this purpose.

The municipal lighting and power plant of Edmonton, Alberta, Can., has been outgrown and will be supplemented by a producer gas-power plant. The first installation will consist of a 700-kilowatt gas engine and alternator, a motor driven air-compressor and a 50-kilowatt gas-engine-driven exciter unit, all furnished by the Allis-Chalmers Company. The present installation comprises Allis-Chalmers generators driven by high-speed engines.

The Ungaynon Engineering Company, 3 Park Row, N. Y., which represents the Albany Industrial Company in Greater New York, New Jersey and the southern States, made contracts in July for installing the Chapman fuel-economizing system in the boilers of the Delaware, Lackawanna & Western Railroad ferryboat "Bremen," and in the boilers of the Christopher street station. This company is also equipping 23 boilers at the Central Islip hospital, and 18 boilers at the Kings Park hospital.

A complete Allis-Chalmers power equipment consisting of two 300-kilowatt generators direct-connected to Reliance engines, a 110-kilowatt generator direct-connected to a high-speed engine, a five-panel switchboard, twenty-four 5-horse-power variable-speed induction motors and a number of constant-speed machines for distribution throughout the plant, was recently sold to the Diamond Match Company for its branch factory at Oshkosh, Wis., all of the apparatus being 3-phase, 60-cycle, 440-volt.

The Power Specialty Company, 111 Broadway, New York, has recently concluded arrangements whereby it has secured the exclusive sale of Duval metallic packing in this country, Canada and Mexico. It will carry a complete stock of this packing in standard sizes, enabling it to fill orders promptly. This company has just received from the press a new and enlarged catalog descriptive of the Foster superheater and other steam specialties including the packing mentioned, copies of which will be forwarded upon request.

James Beggs & Company, of 109 Liberty street, New York, have just put forth a handsome catalog treating of the Blackburn-Smith feed-water filter and grease extractor, which was described in August POWER. This filter is for the removal of sediment, oil, etc., from boiler feed-water, as well as objectionable matter held in suspension in liquids. The subject matter in the catalog is sub-divided under appropriate topics of vast interest to both employer and employee. A copy of the catalog is to be had for the asking.

One of the most complete and modern lines of brass and iron specialties is shown in the new catalog of the William Powell Company, of Cincinnati. This catalog presents the company's line in a complete and practical manner, giving dimensions of every article for which a dimension may be required, and explaining in detail the merits of its specialties. A valuable series of tables and rules is bound in with the catalog, giving in a concise form some information that will be found useful to the engineer and shop manager.

The Green Fuel Economizer Company, of Matteawan, N. Y., recently issued a pamphlet treating of "Drying Materials in Industrial Plants," taking up the drying of various materials, such as fabrics, clothes, malt, lumber, baking powder, paper, pulp, sugar, etc. Besides describing and illustrating the fans, blowers, steam coils and other products of the company, for use in drying plants, an interesting account is given of the philosophy of drying and the text is adequately illustrated. The pamphlet also describes the Green air heater.

The total number of persons employed by the Westinghouse interests at East Pittsburg, Penn., is about 20,000, of which number the Westinghouse Electric and Manufacturing Company employs 16,000 persons. Some idea of the magnitude of the work carried on may be gained from the statement that 1000 car-loads of raw material are received each month, while there are shipped out by freight 600 carloads of the finished product in the same period. This monthly output weighs nearly 100,000 tons. In addition, an average of one carload a day is shipped by express.

The General Specialty Company, 887 Niagara street, Buffalo, N. Y., recently installed special apparatus for the testing of its Demon and Torpedo tube cleaners before being sent out. The Demon machines undergo a brake test and develop the required pulling power before passing final inspection. This is something on the order of the brake tests given by engine manufacturers to ascertain if their product develops the required horse-power. The Torpedo cleaners pass a different test, but equally interesting. Engineers who intend to visit Buffalo, either during the convention of the N. A. S. E., at Niagara Falls, or at any other time, are invited by the company to visit its factory.

The valuable results obtained by the United States Geological Survey at the St. Louis Exposition, in determining the actual steam-making values of American fuels, is being continued with a similar plant at the Jamestown Exposition. The plant has been erected to give an opportunity for analyzing, testing and placing on record in a thorough and comprehensive manner the coals from the Eastern fields. The plant now contains three 300-horse-power boilers, each equipped with an engine-driven 100-inch mechanical draft fan, and a 35-foot stack, both supplied by the Green Fuel Economizer Company, of Matteawan, N. Y. The fans are so controlled that the draft can be regulated as desired by hand or automatically. The wheels of the fans measure 5 feet in diameter by 2 2/3 feet width at the tips of the blades and are driven by 6x7-inch Green vertical center-crank engines. The laying out of the mechanical draft plant was entrusted by the survey to the Green Fuel Economizer Company.

The constantly increasing cost of city water supplies becomes a burdensome expense to manufacturers dependent upon them, but since the art of softening and purifying water to fit it for all uses has been so highly developed, supplies near at hand, which otherwise could not be used, have been made available. The Chartiers creek at Carnegie, Penn., is contaminated with sewage drainage, from coal mines, containing sulphuric acid and carries in solution a considerable quantity of scale-forming matter, so that it is ut-

terly unfit for boiler feed. The Superior Steel Company, of Carnegie, in 1904 installed a 3000-horse-power We-Fu-Go water-softening and purifying system in which to treat this creek water, which was obtained for the cost of pumping it, thus saving the cost of city water, and in addition obtaining a better water. To meet an increase in the boiler plant necessitated by the large increase in the business, a second order increasing the capacity of the present water-softening and purifying system from 3000 horse-power to 7750-horse-power has been placed with the Wm. B. Scaife & Sons Company, Pittsburg, Penn.

The Power Specialty Company, 111 Broadway, New York, announces the fourth edition of its pamphlet on superheated steam, which has been revised by E. H. Foster, inventor of the Foster superheater. This edition contains illustrations of superheaters manufactured by the company as applied to the various types of boilers in use in this country, and also of the direct-fired type, ranging from large illustrations of 3000-horse-power units to small portable superheaters, which may be used for experimental purposes. The pamphlet also contains reproductions of photographs of various parts showing the construction of the Foster superheater in detail; and a few pages are devoted to superheated-steam specialties, such as piston-rod packing, Harter flexible joints, corrugated bronze gaskets, and the Willits double-acting non-return valve, all of which articles are sold by the company as being especially adapted to plants having superheated steam. At the back of the book are steam tables running to high pressures and temperatures, also tables of velocities of steam in various sizes of pipe at different degrees of superheat, and curves for readily selecting the proper size of steam pipe for any set of conditions, which will be found most useful to the designing engineer.

Help Wanted

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

EXCLUSIVE AGENTS wanted in Boston for New England, Philadelphia, Chicago and St. Louis agents to handle a high grade and well known force feed lubricator; only parties with highest references need apply. Box 276, care POWER.

WANTED—A man with experience in the sale of engines and engine specialties, preferably one that has had shop experience and understands how to indicate engines, set valves, etc.; for further information address Box F, Hudson, N. Y.

WANTED—A man who is familiar with steam turbines and reciprocating units; one who is capable of taking charge of central station consisting of electric light and pumping plant; to a good man we will pay from $100 to $125 per month. Box 274, POWER.

WANTED—Experienced man by large manufacturing company for chief operating engineer in new works, State of Washington, 800 horse-power, steam, water-power, alternating current, compressed air and refrigeration; give full detailed experience, age, references and salary. Box 275, POWER.

WANTED immediately by established manufacturing concern, salesman experienced in selling high grade steam specialties particularly to railroad trade; technical education and practical experience in steam practice necessary; state education and experience, where obtained, age and salary desired. Address "Ohio," care POWER.

SALESMEN—We would like to arrange with a few men who are engaged in selling to steam users, to handle in conjunction with the line they now have, or with unemployed engineers, in territory where we are not represented, our fuel economy specialties; we offer attractive commissions to active and reliable men. Address Sarco Fuel Saving and Engineering Company, 90 West St., New York City.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

SITUATION WANTED as superintendent street railway or power house; experienced in inside erecting and outside construction. Box 268, POWER.

MECHANICAL engineer and draftsman with 5 years' experience in boilers, steam turbines, water turbines and governors, as well as shop experience, wishes position. Box 266, POWER.

POSITION WANTED as chief engineer or master mechanic, by an A-1 man with both technical and practical training; an experienced man, no novice; can give results; will go anywhere. Box 272, POWER.

WANTED POSITION as chief engineer of a medium size steam plant, practical and technical education, 9 years' experience, 27 years of age and have my own indicating outfit; best of references. Box 267, POWER.

YOUNG MAN 25 years old desires position as assistant engineer with firm where conditions insure advancement; sober, steady and four years' experience in engine and boiler room; best reference. Ed. Roberts, Eng., Clifford, Ill.

SITUATION WANTED—A first-class stationary engineer of good habits, holds a Philadelphia license and can show good references as to my ability; am 38 years of age and will go most anywhere; 15 years' experience. Box 273, POWER.

A SALESMAN or manager at present traveling in New England; 37 years old; 17 years' experience on engines, boilers and engineers' supplys; best of reasons for making change; satisfaction guaranteed; thoroughly familiar with the business and can give best of references; if you are in need of a hustler to sell your goods, address Box 270, POWER.

ENGINEER, married, age 30, absolutely abstemious, 6 years' experience with alternating and direct-current generators, also understand ice machines, desires position as chief engineer of medium size plant, or assistant in large plant, mill, factory or power company out of town preferred; at liberty Sept. 1. Address "C. K.," P. O. Box 184, Kennett Square, Pa.

WANTED—A position by a young engineer, 26 years of age in an electric light or steam power plant with a chance to work up to chief engineer; have had over three years of experience running engines and firing; have a fair education; am an I. C. S. student and can furnish references and have a city license; am studious and of moral habits. John Bridgeman, 710 Times St., Ballard, Wash.

Miscellaneous

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

IF YOU DESIRE to learn the latest improvement in steam boilers, correspond with the Detroit Water Tube Boiler Co. See their advertisement on page 180.

ENGINES AND BOILERS, ⅛ to 2 h.p. engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make free examination and report if patent can be had, and exact cost.

DESIGN WANTED for a practical, light portable motor, using steam or compressed air; can be of either the rotary or reciprocating type; give full particulars and send blue print. Box 271, POWER.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass avenue, St. Louis, Mo.

For Sale

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

—FOR SALE—Cyclopedia of electricity; five volumes, three-quarters red morocco, leather binding; books are in fine condition; used but short time; cost $19; will sell for $9. Address "R. S. M.," POWER.

FOR SALE—One 13"x18", 125 h.p. automatic Erie City four valve engine; two 50 h.p. Olds gasolene engines; can be seen in operation. Carl E. Schmidt & Co., foot of Lieb street, Detroit, Mich.

FOR SALE—A slightly used engineering library. Steam, electrical, mechanical. Twelve volumes bound in three-quarters red morocco leather. Cost new $60. Will sell for $18. Address "R. L. N.," POWER.

FOR SALE—Cyclopedia of engineering; steam, electrical, mechanical; bound in three-quarters morocco; four volumes; cost new $19; are in fine condition; will sell for $9. Address "M. B. T.," POWER.

HYDRAULIC ACCUMULATOR for sale, measurement 36-9-72, water weighed, running pressure 1500 lbs. to the square inch; never used; just as come from manufacturer. Write Winslow Bros. & Smith Co., Norwood, Mass.

FOR SALE—At a bargain; one length of 1400 ft. and one length of 1240 ft. of 1⅝" diameter; American Transmission Manila rope; in use only three months. Address Harrisburg Light, Heat and Power Co., Harrisburg, Pa.

FOR SALE—One 35-horse-power General Electric motor 500 volt d.c.; one 20-horse-power General Electric motor 500 volt d.c.; these motors are in first-class condition and were taken out solely on account of change in voltage of our power supply. Address "K. V.," Box 269, POWER.

FOR SALE—500 kw. d.c. railway generator, belt driven, three bearing, e. m. f. 550, six pole, 320 r.p.m., serial number 149054, manufactured by the Westinghouse Electric and Manufacturing Company; machine in good condition. For further information, address Detroit United Railway, Detroit, Mich.

FOR SALE—Three (3) 200 kw. 125-250 volt d.c. 3-wire Westinghouse generators direct connected to 16-28-18 vertical compound Ball engines, 200 r.p.m., 150 lbs. steam pressure. All above units are in service and can be seen running; one can be delivered Sept. 1, 1907. Address Wm. G. Boyle, superintendent Oliver Power Plant, H. W. Oliver Estate, Pittsburg, Pa.

FOR SALE—Two 25 kw. direct current 110 volt Crocker-Wheeler generators direct connected to De Laval steam turbines suitable for 125 to 150 pounds steam pressure condensing or non condensing; also one 2200 gallon centrifugal pump direct connected to De Laval steam turbine; this is new machinery. Address The National Cash Register Company, Dayton, Ohio.

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How to Set the Valves of a Duplex Pump

Simple Directions, with Explanatory Diagrams, Including Also the Effect and Treatment of the Cross-exhaust

BY F. F. NICKEL

As is well known, the slide valves of a duplex pump have neither outside nor inside lap. This is necessary to prevent the pump from stopping should the valves be in a position to cover all ports. By making the length of the valve the exact distance from the outside edge to the outside edge of the steam port, and the exhaust cavity the exact distance from the inside edge to the inside edge of the exhaust port, there is only one point in the travel of the valve where the ports are completely closed; and it is not likely, if it ever should happen that both valves were in this position, that the pump would fail to start off, for the leakage of steam past the edges of the valves will never be exactly the same in all four corners, therefore the equilibrium would be destroyed quickly.

By setting the outside edges of the valves "line on line" with the outside edges of the steam ports, the valves will stand in a central position. If, then, both rocker-arms are put in a central or vertical position, the clearance on the valve-rod must be the same on both ends. In Fig. 1 this clearance is shown inside of the steam chest and is marked *C*. On larger pumps, usually, a lost-motion link is inserted between the crank and the valve-rod clevis, which can be adjusted without taking off the steam-chest cover. No fixed rule can be given for the amount of this clearance, as it must be adjusted to suit the working of the pump.

On a pump of ordinary proportion, such as a boiler feed-pump, the total clearance, $2C$, should equal about 25 per cent. of the travel T of the crank-pin at nominal stroke. On a low-service pump (also on a pressure pump for moderate pressure) it is often found that the reciprocating parts are so heavy that the cushion, with the cushion-valve shut tight, is not sufficient to stop the motion of the piston at the end of the stroke. In this case the lost motion should all be taken up. If the piston does not make a full stroke, the lost motion may be increased somewhat above

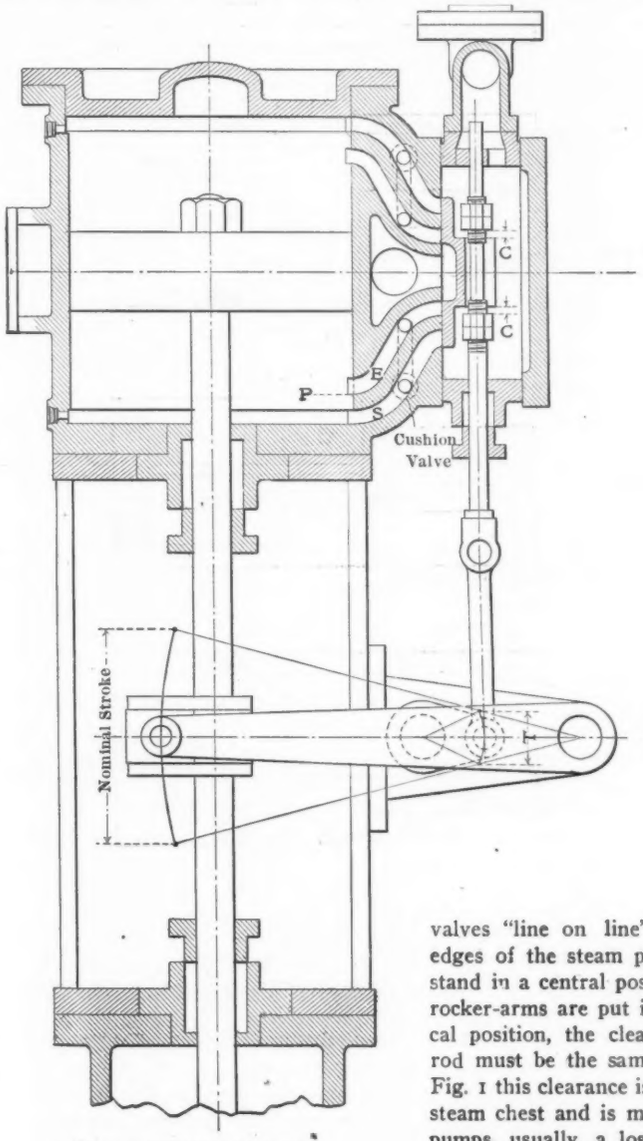


FIG. 1. RIGHT-HAND SIDE

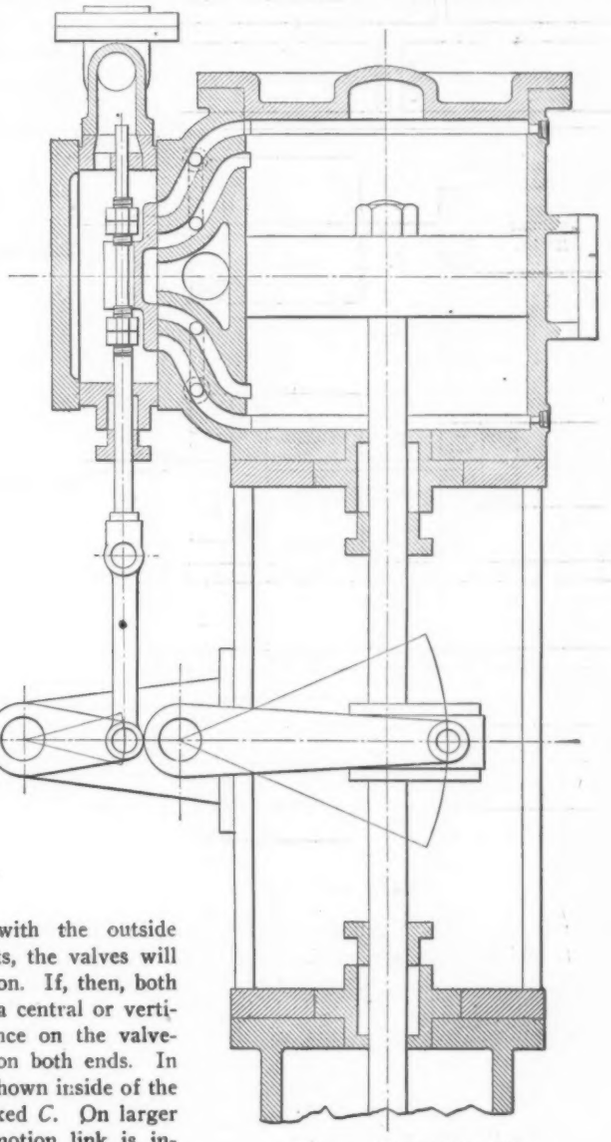


FIG. 2. LEFT-HAND SIDE

the figure given, but it must be kept in mind that this will reduce the travel of the valve and the port opening, and thus may affect the speed of the pump.

The Cross-exhaust Valve

In the case of a compound pump there is still another appliance that can be brought into action to regulate the length of the stroke, and that is a connection, provided with a valve, between the two high-pressure exhaust pipes. The object of this connection is to equalize the pressure in these exhaust pipes and make it more uniform. This is called the cross-exhaust, and its influence on the distribution of steam is clearly shown by Figs. 3 to 8 inclusive: Figs. 3 to 6, inclusive, are convenient sectional plans of the steam cylinders of a compound pump, with the pistons in positions that correspond to lines *A-B* and *B-C* in the diagram Fig. 8. Fig. 7 represents a diagram with the cross-exhaust closed. The steam pressure follows up the full stroke in the high-pressure cylinder, and when the exhaust valve opens it blows into the intermediate space and mixes with the steam left therein from the preceding stroke.

Assuming the intermediate space to have a volume equal to 0.75 of that of the high-pressure cylinder and a cylinder ratio of 1 to 3, we have the following volumes:

High-pressure cylinder = 1; intermediate space = 0.75; low-pressure cylinder = 3.

Clearances are neglected, as it is only intended to show the action of the cross-exhaust. We will also assume that the steam expands according to Mariotte's law:

$$p \times v = \text{Constant},$$

which is sufficiently accurate for our purpose, and assists greatly in getting a clear conception of the behavior of the steam as it passes through the various stages.

The amount of steam passing through one side of the engine is evidently one high-pressure cylinder full at initial pressure. Its measure is $p \times v = 120 \times 1 = 120$ pounds. When the high-pressure exhaust valve opens, this steam flows into the intermediate space, where it meets and mixes with steam that was left there from the preceding stroke. This steam was shut off from its communication with the steam in the low-pressure cylinder when its exhaust valve opened and must be at the same pressure as the steam in the low-pressure cylinder at the point of exhaust. As the ratio of cylinders was assumed to be as 1 to 3, the steam expands 3 times as it passes from the high-pressure cylinder to the low-pressure cylinder, and the terminal pressure is therefore

$$\frac{120}{3} = 40 \text{ pounds.}$$

It will be noted that 120 is a measure for the steam passing through the engine and this amount is accounted for by the indicator diagram at every point of the stroke. Thus we have:

High-pressure cylinder, $p \times v = 120 \times 1 = 120$.

Low-pressure cylinder, $p \times v = 40 \times 3 = 120$.

The amount of steam that is constant and remains in the intermediate space is $0.75 \times 40 = 30$ pounds; the two combined give $120 + 30 = 150$ pounds, which when distributed over a volume of $1 + 0.75 = 1.75$ results in a pressure of

$$\frac{150}{1.75} = 85 \text{ pounds.}$$

This means that when the high-pressure

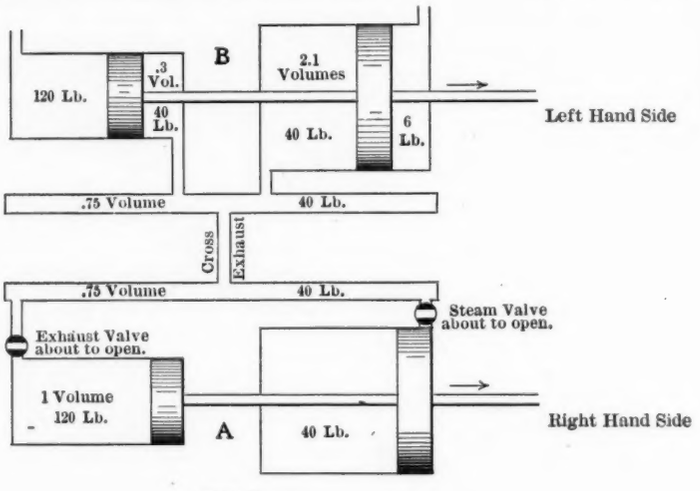


FIG. 3

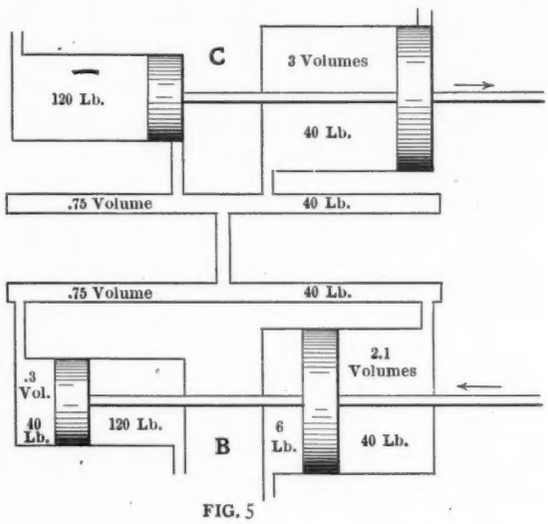


FIG. 5

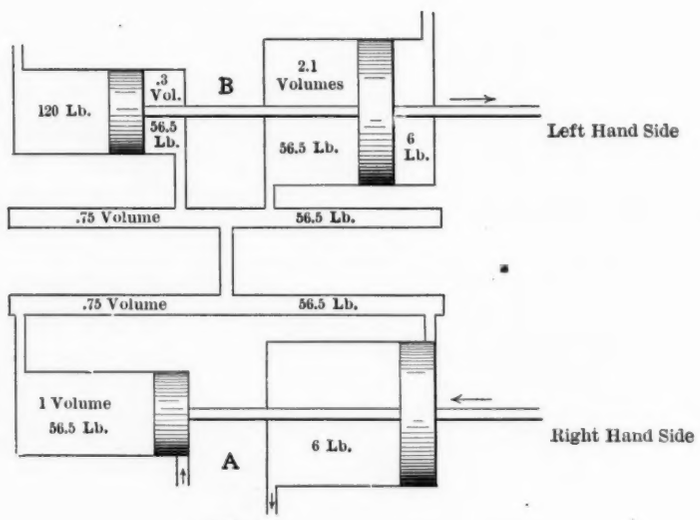


FIG. 4

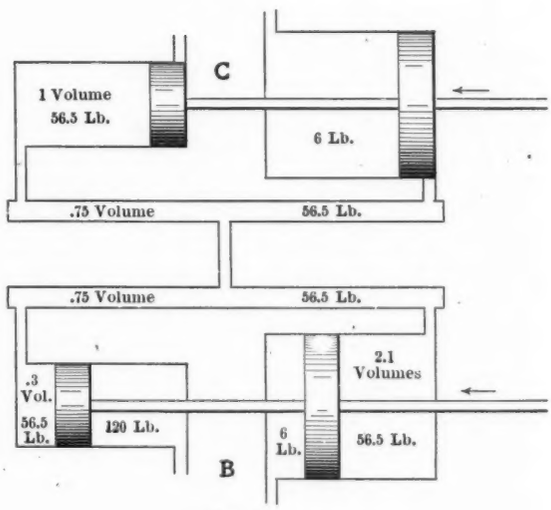


FIG. 6

exhaust valve opens the steam expands from the high-pressure cylinder into the intermediate space from 120 to 85 pounds without doing any useful work. From 85 pounds it then expands from the high-pressure cylinder through the intermediate space into the low-pressure cylinder doing useful work upon the low-pressure piston.

With two points of the expansion curve, namely, 85 pounds at the beginning and 40 pounds at the end of the stroke, it is now easy to construct the remainder of the curve as it is only necessary to complete the rectangle and draw the diagonal. Where this diagonal meets the line of zero pressure, there is point *o*, the zero point of pressure and volume. Any line drawn through this point *o* will give the volume on the line *85*, Fig. 7, and its corresponding pressure on line *A*, Fig. 8.

Under the conditions indicated in Fig. 7, it cannot be expected that an ordinary pump will work satisfactorily, as the following comparison of the steam forces will show:

Beginning of stroke
H. P., 120 — 85 = 35
L. P., 85 — 6 = 79 × 3 = 237

Total steam force.....272 pounds

End of stroke—
H. P., 120 — 40 = 80
L. P., 40 — 6 = 34 × 3 = 102

Total steam force.....182 pounds

The average of the two, or

$$\frac{272 + 182}{2} = 227 \text{ pounds},$$

is a measure of the resistance which, in a pump, is constant throughout the stroke. There is, therefore, at the beginning of the stroke, a surplus of 272 — 227 = 45 pounds, and at the end a deficiency of 227 — 182 = 45 pounds. If, however, the cross-exhaust is opened, it equalizes these two forces to a certain extent and modifies the diagram, as shown in Fig. 8.

With the assistance of Figs. 3 to 6, inclusive, it is easy to follow the steam through its various stages. In Fig. 3 the pistons of the right-hand side have completed the stroke and are about to return. The cylinders on the other side and intermediate spaces are filled with steam at the low-pressure terminal, or 40 pounds. The total amount of steam is then

120 × 1 = 120
40 × 3.9 = 156
Total..... 276

which divided by the volume, 4.9, gives a resulting pressure of

$$\frac{276}{4.9} = 56.5 \text{ pounds},$$

as shown in Fig. 4. This increased pressure gives the low-pressure piston of the left-hand side an additional push and enables it to complete its stroke while the steam expands down to 40 pounds again. Then the steam from the left-hand high-pressure cylinder flows into the intermediate space and raises the pressure to 56.5 pounds in order to help out the right-hand low-pressure piston.

Fig. 8 shows this action clearly, but in practice the rise in pressure will not be as abrupt as shown there, as the pulsations in the pipes will still more equalize the differences and produce a practically uniform pressure in the intermediate space.

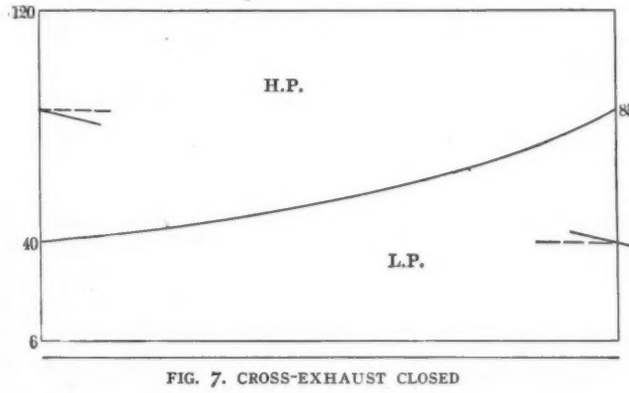


FIG. 7. CROSS-EXHAUST CLOSED

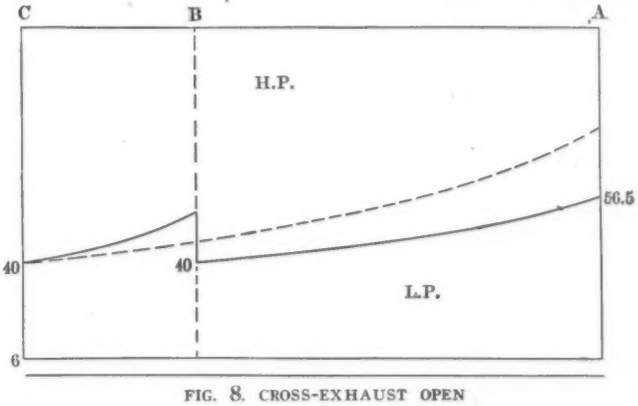


FIG. 8. CROSS-EXHAUST OPEN

It will also be noted that by opening the cross-exhaust, pressure is removed from the low-pressure piston and shifted over to the high-pressure piston, which results in a loss of power and reduced speed of the pump.

The cross-exhaust should therefore be kept closed whenever the pump runs fairly well in this condition.

Sub-station Troubles

By A. Wohlgemuth

In considering the various troubles of sub-stations, it must be borne in mind that the "sub-station" is, as its name suggests, subordinate to the generator station, and that troubles which occur at the latter will affect every sub-station to which it supplies current. At the same time, a sub-station may have local trouble, due to a breakdown of part of the apparatus, or other cause, which may do a lot of damage, and will certainly be a source of worry and inconvenience to the operator. Therefore, troubles occurring at sub-stations may be divided into two general classes, namely, those caused by a breakdown at the generator plant, and troubles originating at the sub-station itself.

The most serious sub-station trouble is the complete interruption of the supply current, caused by a shut-down of the generator station through a breakdown at the steam plant, or due to a fault in the transmission apparatus. When a shut-down is caused by steam trouble, the interruption at the sub-station will not be sudden; there will be a gradual slowing up of the rotary converters, a corresponding drop in load, and finally when the ammeter shows zero, the converter, if kept running, will send out current instead of receiving current. Under these conditions the operator must open all switches which connect the sub-station to the generator station, and make all available use of his storage battery, if there is one. If the converters in the sub-station are started with induction motors, the best thing the operator can do is to shut them down immediately; but if they are to be started as direct-current motors, it is best to keep them running until it is absolutely certain that the generator station is down and out. That this is a good plan to follow has been proved to the writer by long experience, for there have been many cases in which all indications pointed to an indefinite shut-down, yet contrary to indications the interruption lasted only a comparatively short time. In such cases, when the converters were shut down, it was very difficult to get them into operation again and much valuable time was lost.

If, however, a shut-down is caused by electrical trouble, such as grounded feeders or a short-circuited generator or armature, the effect on the sub-station will be altogether different, and the operator must act accordingly. The first indication of trouble will be an unearthly howling in the converter, accompanied by a spitting and sparking at the commutator and collector-rings of the machine, a tremendous increase in its speed and a great fluctuation in the load, while the needle of the

ammeter will swing out of sight in both directions. Under such conditions the operator can do very little. He must wait for the automatic safety devices to operate, and if the relays, circuit-breakers, etc., are in good working condition, the switches will open, one after the other, until the sub-station is shut down. Of course, there is always a possibility that one of the automatic safety devices will refuse to operate at the critical time, and then it is the operator's duty to keep cool, use good judgment and open the right switch at the right time.

A few years ago the writer was in the midst of the trouble caused by a high-tension short-circuit, which shut down all the converters but one and then wrecked that machine to such an extent that there was nothing left of the machine but the frame. This shows that no matter how many automatic safeguards a machine is surrounded with, in a great many instances it is "up to" the operator to pull switches, *if he gets a chance.*

When the trouble at the main station is over, if the converters in the sub-station are started by means of induction-motors, it is simply a matter of ordinary operating to get things back into shape, but if the converters are started from the direct-current bus-bars, it is quite a different proposition. By the time the generator station is ready to supply current again the storage battery will usually be discharged, except for a small amount of energy which can be utilized to excite the field magnets of the converters. Then there is nothing to do but to connect the converters with the mains from the generators at the main station, leaving the field switches of the converters open. When the generators are started the converters will start with them, and will speed up as the generators speed up; then the converter field switches must be closed. The most important point for the operator to attend to then is to see that the polarity of the converter brushes is right, in reference to the system. If the polarity is correct, it is plain sailing. The machine will pick up as much load as the generator station will permit, until the pressure is normal.

If, however, the brush polarity is reversed, the operator faces a rather serious problem. The best method which the writer knows of to meet that condition is to open the field switch of the converter and close it again after a short interval. This, in all cases observed by the writer, served to reverse the polarity. It is not the purpose to go into details as to the causes of the reversed condition, nor to attempt to describe the effect on armature polarity of opening and closing the field circuit; that operation will surely remedy the fault, however. After the first converter is carrying load, it is simply a matter of routine work to get the other converters into step until conditions are again normal.

The trouble just described at length is practically the only one to which sub-stations are liable, due directly to a breakdown in the generator plant. While the causes of breakdown in the main station are numerous, the effects on the sub-station will invariably be similar to those described, and the remedies should consequently be the same.

Causes and Effects of Local Troubles and How to Overcome Them

One of the most important pieces of apparatus in a sub-station and one which will give the most trouble, if not watched carefully, is the automatic device known as a relay, used to open high-tension switches in case of trouble on the line. The relay is but a delicate instrument at best and requires constant care and attention to make sure its operation at the critical time. It is impracticable to describe the various types, but a general outline of the treatment which all relays ought to receive will be useful.

They must be tested at least once every week and reset at regular intervals. One fault which, while not of frequent occurrence, is a very serious one, is the open-circuiting of the current transformers to which the relay coils are connected. This fault, of course, puts the relay out of business altogether, and is mentioned to show the importance of frequent current-transformer tests. If on test the relay refuses to perform its work, nine times in ten the fault will be found in the wiring from the control-board to the relay. It will usually be either a loose connection, an open circuit or a grounded wire. In many instances the metal relay-cover has accidentally got into contact with the wiring, which, while it may not cause immediate trouble, is liable to operate the relay and open the switch when least expected.

The oil switches, of which several types are in use, are another source of trouble. This is a complicated apparatus, mechanically and electrically, and it would be beyond the scope of this article to describe it sufficiently to properly discuss its troubles and their remedies, but of all the faults in oil switches about three-fourths are mechanical. If an oil switch fails to operate from any other reason, it will be due in most cases to faulty and careless wiring.

If treated rightly, the rotary converter will give very little trouble. The most frequent source of mischief is the collection of copper dust at the collector-rings and brush rigging. If copper dust is allowed to accumulate (and it will do so rapidly if the brushes are not set properly), grounds and even short-circuits between phases will result. The only way to prevent this trouble is to have the brushes set properly and employ cleanliness. After every run dust and other foreign substances should be blown out of the converter with compressed air, or if that is not available, with hand bellows. The brush rigging should be carefully examined and every trace of copper dust removed. It is also essential to see that the brushes are firmly held in their holders, for if not, the brushes may be jarred out, and if one should happen to fall across two collector-rings serious trouble would result. The commutator of a rotary converter should receive the same treatment as any other commutator, but if the brushes are set properly with reference to tension, alinement and neutral position, very little trouble will be experienced.

The transformer is one of the most reliable and least troublesome of the apparatus used in sub-stations. In a long experience not more than two, or perhaps three, serious accidents to transformers are recalled, and these were caused by a breakdown of the air apparatus. With very few exceptions modern sub-stations are equipped with air-blast transformers, and if there is a breakdown of the motors or blowers which supply air, there is generally serious trouble, although most stations are equipped with duplicate motors and blowers. Still, in some cases, a shut-down of a blower motor may cause a shut-down of the entire rotary-converter plant.

A very peculiar fault which is liable to develop is the open-circuiting of the leads connecting the primary coils of the transformer to the line. While this is not a transformer trouble in the real sense of the word, if not noticed in time it may lead to the burning out of other transformers. In one instance the middle transformer of a three-phase converter was cut out and the converter continued to carry its load on two phases. There was a slight momentary fluctuation of load, but as the ammeter immediately became steady again, nothing was thought of it at the time. About half an hour later the converter attendant notified the operator that the two outside transformers on that particular converter were dangerously warm, while the middle one was cool. An open circuit in the primary leads was found and the converter was shut down. If the conditions had not been noticed in time, without doubt it would have resulted in burning out one or both of the outside transformers.

If from any cause an air-cooled transformer should start to blaze, the air blast must be shut down immediately. In many cases, where one blower supplies a bank of several transformers, this is not possible, as it would shut off air from the other transformers. In such circumstances the attendant must shut all the dampers of the burning transformer and fill it with sand to the very top. This will smother the fire, and while the transformer may smoke until the blower can be shut down, all danger of setting fire to the wiring or to other transformers is eliminated.

The Storage Battery

From the operator's viewpoint, the part which will give the most trouble, in the

operation of a sub-station storage battery, is the end-cell switch. This switch in early battery installations was altogether hand-controlled, but most end-cell switches are now operated by motors, necessitating the installation of automatic stops, reversers and limiting switches. That this addition increases the possibility of trouble is undoubtedly true, as there is always danger that some one of the automatic devices will give out when most needed.

Very often the stopping of the switch brush between two cell contacts, caused by the failure of the automatic stop, results in a short-circuit which, if the switch is not moved in time, will melt off the auxiliary contacts and damage the switch considerably. In such a case the only thing to do is to move the switch by hand, by means of the wheel which has been left in service on all motor-driven switches for just such emergencies. It is only a matter of how quickly the operator can get to the switch as to the amount of damage which may be prevented. When the battery is wanted in a hurry, such as during a breakdown of a converter, it is not very pleasant to have a switch stuck between cells (and they have a habit of doing that). The best way to prevent this is to look over the switch and its mechanism every day and make sure that every part works properly; the result will pay for the trouble. In fact, by constant overhauling and watching, and by renewing any part the worse for wear, trouble with end-cell switches can be reduced to a negligible quantity.

The booster, although a special machine, because used in sub-stations for charging, and in some cases also for discharging, is nothing more than an ordinary motor and dynamo, and must be treated as such. With ordinary attention the booster will give very little trouble.

In conclusion it is only right to mention the responsibility of the operator at all times, and especially in times of trouble. In the latter case, if he uses good judgment and does not get "rattled," there is no doubt that the resulting damage will be very slight; but an excited operator may cause a shut-down. It seems strange, but it is a fact, that as soon as trouble strikes their station, a great many operators imagine that trouble is "up to" them, that is, that they are in some way to blame; this, of course, has a tendency to make them nervous, and generally leads to an error which may be costly. The best operators are those who know their station thoroughly, understand the functions of all the apparatus, and when in trouble do the best they can.

In order to cause paint to adhere better to galvanized iron, the United States Government has adopted the plan of first applying vinegar to the surface to be painted, which roughens or corrodes it sufficiently to afford good adhesion.

A New Idea for an Internal-combustion Engine

An ingenious idea in the way of gas-engine design is embodied in the type of engine indicated by the accompanying illustrations. This type has been patented in England by H. Campbell, of Dumbarton, N. B., and was recently described in *The Mechanical Engineer,* of Manchester and London.

Fig. 1 is a sectional elevation of the cylinder of a single-acting engine, and Fig. 2 the cylinder of a double-acting engine, as they would be constructed in accordance with Mr. Campbell's patent. In the single-acting engine, *C* is an exhaust port fitted with a mechanically actuated valve *D*, and *E* is an admission port, located approximately midway of the stroke of the piston and provided with an admission valve *F*, which is closed by a spring *G*; *H* is a passage which communicates with a supply of mixture under pressure. In the illustration the piston *B* is shown in its bottom position, the top position being indicated in dotted lines, and it should be noted that the piston is sufficiently long to cover the admission port *E* when in its top position. In action, with the piston beginning to rise on a compression stroke, the exhaust valve *D* is held open until the cylinder has received a charge of mixture which will flow in past the admission valve *F*, the pressure in the supply passage *H* being sufficient to overcome the reduced pressure in the cylinder of the previously expanded charge and the resistance offered by the admission valve. The exhaust valve *D* is mechanically closed at an early period in the compression stroke of the piston, and the incoming charge is cut off by the automatic inlet valve *F* when the pressure within the cylinder is nearly in equilibrium with the pressure in the supply passage *H*. The charge is then compressed by the rising piston and subsequently ignited to produce the power stroke. When the power stroke is nearly completed, the exhaust valve *D* is opened to release the pressure in the cylinder, and when it has fallen below the pressure of supply the automatic valve *F* opens and a new charge flows into the cylinder, the charge being completed after the exhaust valve is closed.

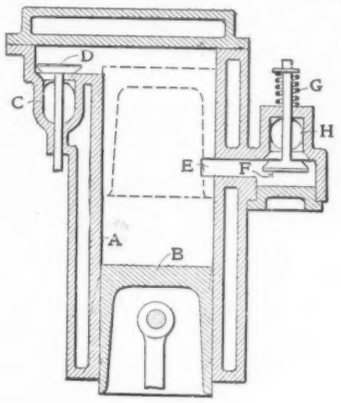


FIG. 1

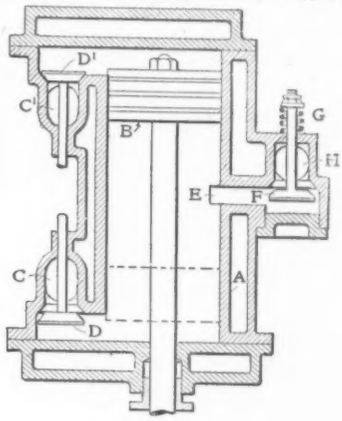


FIG. 2

In conjunction with this cycle of operations it will be noted that as the port *E* is situated at a distance above the head of the piston when it is down, during the compression stroke a portion of the charge, after partial compression has taken place, will be entrapped in the valve chamber and port opening *E* as the piston advances and remain trapped until the piston again passes the opening on its return or power stroke, when the entrapped charge will be ignited as it becomes exposed to the live charge and produce a supplementary power effort at a stage when the connecting-rod is at effective angle with the crank.

Referring to Fig. 2, in which the cylinder of a double-acting engine is illustrated, *C* and C^1 are end exhaust ports fitted with mechanically actuated valves *D* D^1, and *E* is the admission port, located approximately midway of the piston travel, as before. The port *E* is fitted with an automatic inlet valve *F*, and *H* is a passage which communicates with a supply of mixture under pressure, as in the previous case. In this form of construction, a comparatively short piston is employed. In action, with the piston in the position shown and beginning to descend on a compression stroke in the lower end of the cylinder, the exhaust valve *D* is held open until the lower end of the cylinder has received a charge of mixture which will flow in past the valve *F* as in the cycle of the single-acting engine already described. The exhaust valve *D* closes in the initial movement of the piston, after which the charge will be compressed, and in the advance of the piston the admission port *E* will be brought into communication with the upper part of the cylinder where a power stroke is in progress. With this difference of operation the cycle of action is similar to that in the single-acting engine. The adjunct, however, differs in this case from that in the cycle of the single-acting engine, in that when the port or opening *E* is constructed to receive a portion of the charge in compression the entrapped charge is ignited during the same stroke by the live charge on the opposite side of the piston as the piston passes and uncovers the port.

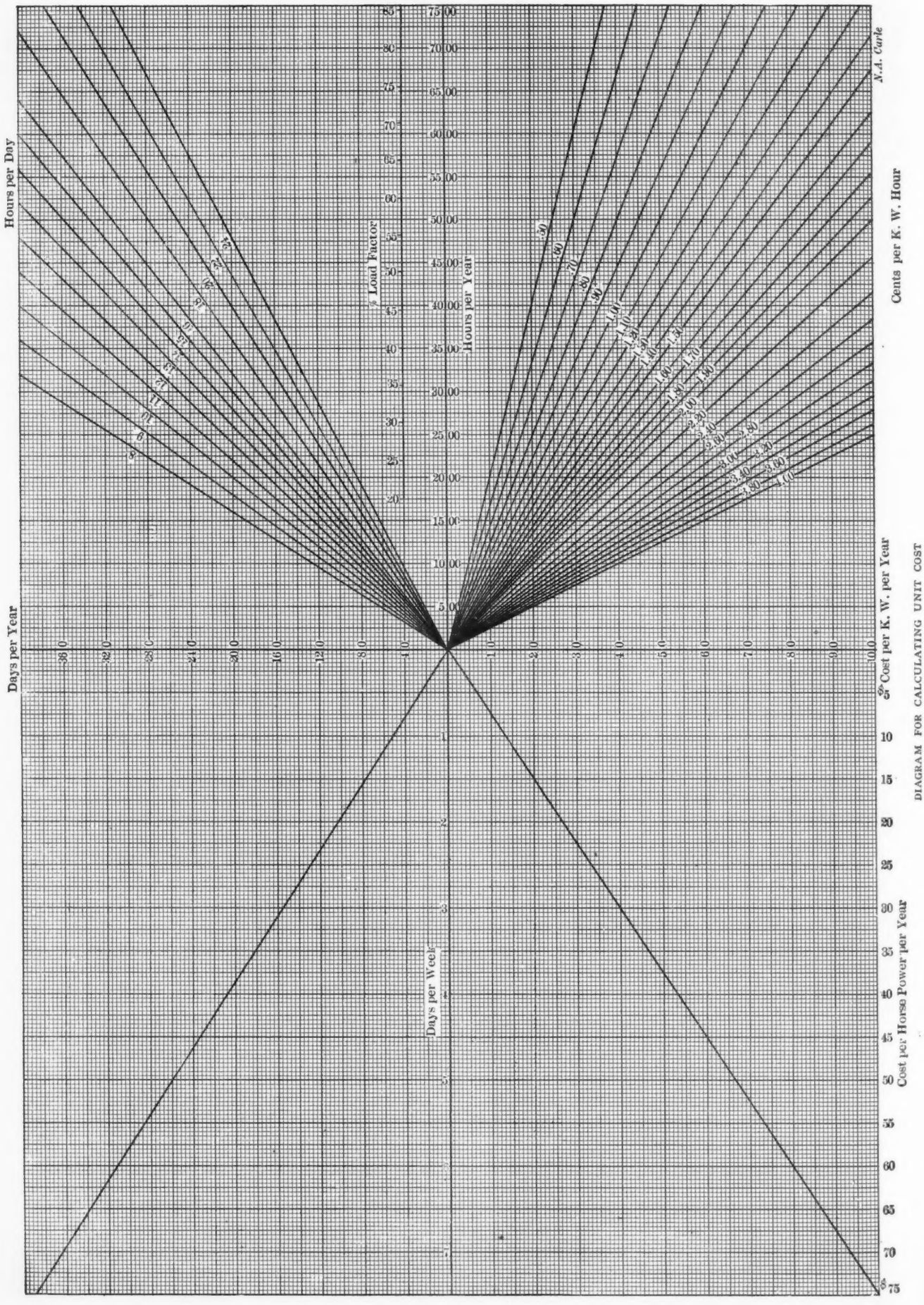


DIAGRAM FOR CALCULATING UNIT COST

The ventilating ducts in the armatures of machines should be kept free from dust.

The bearings should be given intelligent attention. In handling the armature be careful to not injure the shaft so as to cause a rough surface which will cut the bearing and roughen it. Heating will follow, and the only remedy is a new bearing. Dust or iron filings, if permitted to enter between shaft and bearing, will soon injure the latter.

Care of Commutator

It is extremely important that the commutator be kept free from oil and dirt. Wipe the commutator daily with a piece of dry canvas. It is not advisable to use waste for this purpose. No further attention is necessary, provided the commutator polishes and there is no sparking at the brushes. In case the surface does not take a smooth polish a lump of paraffin rubbed across the surface once a day while the machine is running will supply all the lubrication necessary. Care should be used that the paraffin does not collect about the brushes or on the surface of the commutator. If the commutator becomes very rough and the insulation projects above the bars, a piece of ordinary sandstone may often be used effectively. One surface of the sandstone should be ground to approximately the same curvature as the commutator and then held firmly against the surface while it slowly revolves.

Flat spots, or "flats" sometimes occur on commutators. They are usually caused by excessive wear, by too much end play, by a loose commutator, or a bad belt splice, or sometimes by a flash produced by a short-circuit on the line. If the commutator becomes "out of true" it must be turned down. To do this the armature should be placed in a lathe. The best speed in turning down the commutator is from 500 to 600 feet per minute. A diamond-point tool, set with its cutting face at right angles to the surface, gives the smoothest finish.

After long usage and much wear a commutator will sometimes become hot when carrying but the normal load of the machine. This may indicate that it has been worn down as far as it is safe to go, and the commutator should be replaced by a new one.

It is convenient to remember that if the charge taken in by a gas engine be compressed to one-sixth its original volume, that is, if the compression ratio be 6, the compression pressure will be ten times the pressure of the charge before compression. Thus, if the suction pressure be 13½ pounds absolute, and the compression ratio be 6, the compression pressure will be about 135 pounds absolute. This compression pressure is very often used in engines for operation on producer gas.

Fuel-testing Plant of the Geological Survey at Jamestown

The fuel-testing work of the United States Geological Survey, which was begun at the St. Louis World's Fair, has been transferred to the Jamestown Exposition, where it is conducted in the Power and Alcohol building. Much of the apparatus used was transported from St. Louis. The new installations include a 250-horse-power Babcock & Wilcox boiler, with superheater, equipped with a Roney stoker; a Jones underfeed stoker, added to one of the old Heine boilers; two direct-current De Laval turbine sets rated at 300 horse-power at 9000-900 revolutions, and three Green fuel economizers.

The method of work in the steam-engineering section has been slightly changed so that instead of testing a great number of coals more tests are made of each coal, noting the results with different sizes, different methods of stoking or feeding, etc. The Babcock & Wilcox boiler has been placed beside the two Heine boilers, and all three provided with induced-draft apparatus in order to get a wide range of capacity. The Babcock & Wilcox boiler was installed partly to enable tests to be made of the same fuel with different types of boilers. The baffles in the Heine boilers have been re-arranged or partitioned so as to practically double the length by compelling the heated gases to pass along the entire length of the tubes twice. The steam-engineering division is also carrying on tests to further determine the performance and efficiency of the furnace alone.

In the producer-gas section, in which the Westinghouse gas engine transferred from the St. Louis plant has been installed, slight changes have been made in the gas-producer apparatus. For instance, one of the producers has been provided with a water-seal at the base to permit the ashes to be removed without admitting air, and several holes have been drilled at different hights, to be used for extracting gas samples. The purifying apparatus used at St. Louis, which consisted of a vessel containing iron filings and wood shavings, has been removed, since experience indicates that the danger from impurities has been considerably exaggerated. To insure steady water pressure, a special stand-pipe has been provided.

The gas engine is bolted to a 200-kilowatt Bullock generator brought from St. Louis, which serves to drive the motors for the apparatus in the building, the machine shop, the briquet plant, the elevators and the conveyer. Any additional load required is obtained by means of a water rheostat, which can be adjusted by the switchboard attendant, so as to maintain a steady full-load value. The plans of this section include the following determinations: The proper length for a test run, the effect of the size of the coal, the best depth of the fuel bed, the effects of rapid load variations, the maximum returns from different fuels, and the response of a producer plant to sudden demands for power.

In the alcohol-, gasolene- and gas-engine section, new work of importance is being undertaken. The equipment of this section includes two 15-horse-power Otto gas engines, running at 250 revolutions per minute, two 15-horse-power Nash engines, one 2-horse-power International Harvester Company's engine, and two John Deere engines rated at 14 and 18 horse-power. While experiments covering the whole range of the field will be made, at present the work is confined chiefly to examinations of different carbureters, with the object of determining the lines along which more efficient vaporization may be obtained.

Unit Cost Calculator

By N. A. Carle

In speaking of cost of electrical power, it is usual to state it at so many cents per kilowatt-hour. This value depends upon the yearly cost of a horse-power, or a kilowatt, and the number of hours of service per year. The ratio of the total hours of service to the total hours in a year is called the load factor.

The chart on page 662 is designed to give directly the cost per kilowatt-hour for electrical service when the yearly cost is known either in horse-power or kilowatts, and the service is expressed in hours per day and days per week, or as a load factor.

Example

What would be the cost per kilowatt-hour of electrical service that costs $45 per year per horse-power, the plant operating 6 days per week and 16 hours per day?

Starting with $45 "Cost per Horse-power per Year," read up to the line above this value, then across through $60 "Cost per Kilowatt per Year," and extend this line across the lines marked "Cents per Kilowatt-hour." Then starting with 6 "Days per Week," read up to the line above this value and across to 16 "Hours per Day," and the intersection of a vertical line through this point with the horizontal line mentioned above will give $1.20 per kilowatt-hour.

Example

With a load factor of 40 per cent., what would be the yearly selling price of a horse-power at a rate of 2 cents per kilowatt-hour?

Starting with 40 per cent. "Load Factor," read down to 2 "Cents per Kilowatt-hour," and across through the value of $70 "Cost per Kilowatt per Year," and down to $52.50 "Cost per Horse-power per Year."

Installation and Operation of Direct-current Motors and Generators *

There is no mechanism composed of moving parts which will operate as long and as efficiently with so little care and attention as an electric machine. It does not follow, however, from this that such machines will run as efficiently when neglected and abused as when given proper and intelligent care. On the contrary, the superior efficiency of electric machines over all others can only be attained by their careful installation and intelligent operation.

Installation

The location of the motor or generator is the first step in its installation and one which, if properly taken, will avoid many future troubles. The machine should be placed in a spot free from dust and moisture and from extremes of heat or cold. About 70 degrees Fahrenheit, ordinary room temperature, is the best thermal condition for the machine if it is to run with normal temperature rise.

The foundation, even for small machines, should be solid so that there will be no vibrations at any speed. Whenever feasible, bolts which fasten the machine to the foundation should not come in contact with any electrical conductor, and the supports under the machine should be covered with insulating paint. The foundation should also be carefully leveled and be of a material that will neither draw nor retain moisture. Most machines can be mounted securely on wooden foundations which are cheap and easily made, besides being good insulators.

The unpacking of the machine should be done carefully in a room of moderate temperature. If the machine has been exposed to moisture it should be dried out before being put in service, either by baking several hours in a moderately warm oven, or by sending a current equal to one-half full-load amperes through the armature and field until the insulation is thoroughly dry.

The motor should be carefully leveled and lined up with the machine which it is to drive. If there is belt drive, the shafts of the motor and driven machines must be parallel and the pulleys in exact alinement. If the shafts are not parallel the belt will tend to run to one side of the larger pulley even if the two are in line. If the pulleys are out of line the belt will tend to run off the smaller pulley even if the shafts are parallel. The belt should be put on with the smooth side next to the pulleys and in such a way that it will pass over them *with* the lap and not *against* it.

It is important to remember that the speed of a series-wound motor will increase indefinitely as the load is decreased and at or near no load may become so excessive as to endanger the armature. For this reason it is not generally advisable to connect series-wound motors to their work by belts. When belts must be used they should be wider than required by ordinary practice.

Operation

In starting up a motor proceed as follows:

First—See that the bearings are well filled with oil.

Second—See that oil-rings are down on the shaft and working smoothly.

Third—Be sure that brushes are making good contact and have proper tension.

Fourth—Close the line switch.

Fifth—Move the handle of the starting box forward as rapidly as the motor will respond in speed.

The direction of rotation of motors can be changed by reversing the armature or field connections, but not both. It is usually more convenient to reverse the armature connections, and this is standard practice. In compound-wound motors the direction of rotation in starting is determined by the connections of the shunt field winding which is usually stronger than the series field winding. If there is a wrong connection of the series field winding, that is, if the current is passing through the winding in a different direction from that in the shunt winding, the speed of the motor will *increase* when the load is thrown on. In this case reverse the series field connections.

In starting a generator proceed as follows:

First—Take the same precautions as regards bearings and brushes as in starting a motor.

Second—See that all resistance is in the field circuit.

Third—Open the field switch until the machine is up to normal speed.

Fourth—If starting up for the first time, make sure that the connections are as shown by the maker's diagram; otherwise the generator will not "pick up" voltage.

Fifth—Start the prime mover slowly.

Sixth—When starting a compound-wound generator for the first time it is advisable to see that the shunt and series field coils are properly connected.

In stopping a motor the order of operation is:

First—Turn field rheostat to "out" position.

Second—Open the line switch.

Third—Slowly open the field switch.

Too sudden opening of the shunt field circuit of a motor may cause "flashing over" at the brushes which blackens the commutator.

In stopping a generator the proper order is as follows:

First—Reduce voltage by putting in resistance in the field circuit.

Second—Open the line switch.

Third—Shut down the prime mover.

Fourth—Open the field switch.

It is well to always follow *a definite order* in the operation of switches. The habit of closing and opening switches in this sequence will save errors and possible repairs to the machines operated. Keep all switches open when machines are not running. Do not throw switches shut violently, but close them carefully, keeping hold of the handle until the switch is firmly closed.

Care of Brushes

Quite frequently poor commutation has its origin in inattention to the brushes. The contact surfaces of all carbon brushes should fit the commutator surface. Sparking may result if the brushes do not make good contact. The brushes may be ground to fit the commutator by using a piece of emery cloth which is put over the commutator under the brush with its rough surface outward. Keep the cloth close to the commutator so as not to round off the brush edges, and either turn the armature slowly or pull the cloth over the commutator by holding each end. When the brush is roughly ground, finish the surface by using fine sandpaper in place of the emery cloth. Remove all carbon dust from the commutator before starting the machine.

Carbon brushes should fit the brush-holder snugly, but not so tightly as to become wedged and prevent the carbon pressing on the commutator with the desired tension. If the brush is too tight, grind off the side which binds with sandpaper until the brush slips into the holder easily.

The brushes on motors are given a "backward lead," that is, are set a short distance from the "neutral point" on the side which is opposite to the direction of rotation. If this distance be increased, the speed of the motor increases and *vice versa*. In the case of generators the brushes have a "forward lead," they being set off of neutral in the direction of rotation. An increase of this lead will cause the generator voltage to decrease and *vice versa*. Never operate motors with a forward, nor generators with a backward, lead.

The brush-holder should be tight on its support, and the tension of the spring adjusted to about two or three pounds.

Care of Armature and Bearings

Armatures should be protected carefully from mechanical injury. The magnetism of the pole-pieces will attract and hold small pieces of loose metal, such as iron filings, nuts, bolts, etc., and if the latter get between the armature and field core they may cause serious damage to the former by cutting and bruising insulation, resulting in grounds and short-circuits.

*Abstract from an instruction book issued by the Westinghouse Electric and Manufacturing Company.

Technical Aspects of Oil as Fuel—I

Liquid Fuels, their Treatment and the Formation of Combustible Mixtures, with Regard to their Application in Power Plants

BY FRANZ ERICH JUNGE

I have treated of the commercial aspects of oil as fuel for power generation in an earlier article*, and it was my intention to add to this first essay—in which the superiority of the lower grades of oil over the higher species and especially over the modern competitor, alcohol, was developed—a second part dealing with the technical aspects of the problem; in particular, with the cyclic processes and with the mechanical appliances that have been proposed for their execution in the course of time.

Hydrocarbons of the Paraffin Series (C_nH_{2n+2})
Vapor Volume and Boiling Point.

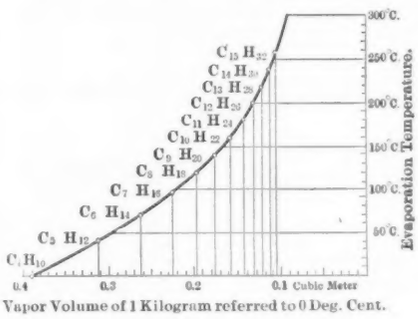


FIG. 1

In studying the technical literature pertaining to this subject, I find that it has found most careful and exhaustive treatment in Germany, the home of the Diesel, the Haselwander and other oil engines of economic distinction. As a matter of fact, I find little to add to what was presented, a short while ago, to the *Verein deutscher Ingenieure* by Karl Kutzbach in a masterly paper on "The liquid fuels and their utilization in internal-combustion engines, with special consideration of the Diesel engine." I shall therefore restrict my remarks in the discussion of this paper to such phases of the subject in which my experience with the application of oil for internal-combustion purposes has evolved different ideas and novel appliances.

Advantages of Liquid Fuels

It is known that the superiority of liquid fuels over solid and *gaseous* fuels is founded, primarily, on their greater heat density, that is, the larger number of calories available per unit of space. Thus we have in petroleum 10,000 calories condensed in a space of 4/5 of a liter, whereas in ordinary coal and coke the same number of calories occupy a space of from 2 to 4 liters, in lignite or brown coal from 6 to 10 liters, and in peat and wood even more. Another advantage consists in that the liquid fuels can be obtained sufficiently purified so as not to leave any appreciable amount of residues in the prime mover and pipes, while solid fuels always contain a considerable proportion of incombustible materials, such as ashes and slag, and gaseous fuels, except when obtained through the gasification of high-class lean coals, contain tarry constituents, dust, water and other undesirable elements, the elimination of which requires at times the expenditure of a great deal of money on the part of the power user; thereby rendering the investment for a gas-power equipment unprofitable compared to that of a plant driven by liquid-fuel motors, especially when the latter is operated intermittently and the standby losses are taken into consideration. Last but not least there is this desirable feature about oil and kindred fuels, that they can be pumped through pipe lines over long distances, with self-controlled stability of transportation conditions and without considerable cost, as is done, for instance, from the oil fields of Kansas directly to the storage tanks of the Standard Oil Company, in New York and Chicago. With coal, whether raw or in briquets, the transportation factor is no negligible quantity, less on account of the *cost* element than on account of the dependence of the consumer on the arbitrary measurements and accidents of railroad traffic.

A New Class of Coal-oil Fuels

In addition to the ordinary crude oil, petroleum and gas oil, which fuels, in addition to gasolene, have been used so far almost exclusively for the generation of power in smaller units, we have, in Germany, the oil derivates from brown-coal tar, and those from slate, and quite recently we are beginning to use the coal oils which distil over as by-products from ordinary coal tar. This mode of utilization of tar is a most interesting one, and of greatest commercial bearing, yet it is only in its infancy now. It should be noted that this class of coal-tar oils embraces a vast number of species, all of which show different physical and chemical properties and behave differently also in regard to their application for driving internal-combustion engines. As to the

EVAPORATION CURVES OF SOME FUEL OILS

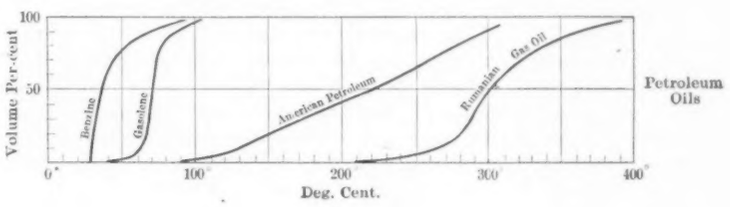


FIG. 2

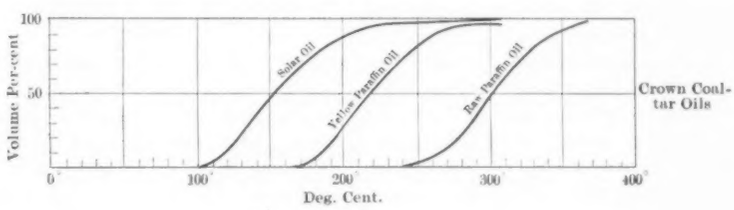


FIG. 3

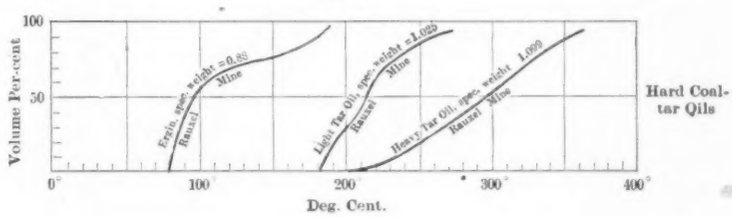


FIG. 4

*"Commercial Aspects of Oil as Fuel for Power Generation." By F. E. Junge. POWER for March, 1907, page 137.

latter purpose, it should be kept in mind that the combustion of the oil is preceded by an evaporation, and that it is this property to evaporate which determines the mode and realm of application of a certain oil for certain uses. For general power purposes the hydrocarbon compounds of the paraffin series ($C_n H_{2n+2}$), or of the ethylene series ($C_n H_{2n}$) are the best applicable.

Evaporation Characteristics of Liquid Hydrocarbons

In Fig. 1 are plotted on the horizontal

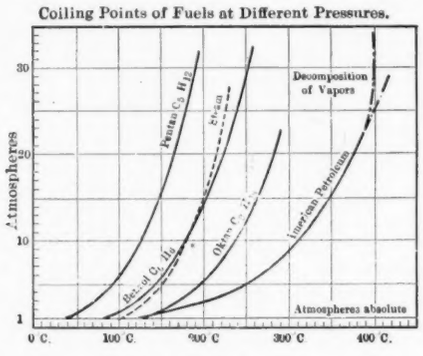


FIG. 5

line the volumes corresponding to the weight of 1 kilogram of the respective oil vapors. They have all been reduced to the common basis of zero, Centigrade, though they cannot, of course, exist at that temperature. On the vertical ordinate are plotted the evaporation temperatures or boiling points of the more important hydrocarbons at atmospheric pressures; $C_5 H_{12}$, and farther up to $C_7 H_{16}$, are the principal constituents of the benzine and gasolene class. The other compounds up to $C_{16} H_{34}$ and beyond form the principal constituents of the petroleum class of oils, with higher boiling points. The compounds from $C_{17} H_{36}$ up to $C_{27} H_{56}$ are contained in the solid paraffin, which is a non-liquid at ordinary room temperatures. It will be seen from the curve that when the volume of the vapor per kilogram of oil decreases, in other words, when the density and therefore the specific weight of the vapor increases, then the boiling point rises considerably, so that higher and higher temperatures are required for evaporating the liquid oil.

The fuels which are used for power generation are always mixtures of several of these various compounds. In analyzing some of them Kutzbach has found the characteristics indicated by the evaporation curves shown in Figs. 2, 3 and 4. The evaporated volume in per cent. is represented on the vertical scale, and the temperatures which prevail under the respective volumetric conditions are plotted on the horizontal scale. The curve for American petroleum reveals at once the characteristic fact that it contains a greater number of hydrocarbons, from the lightest to the heaviest, than any other oil. Also that the heavier paraffin and tar oils evaporate only at temperatures above 350 degrees Centigrade. So there is danger that the light and readily combustible constituents of such an oil will evaporate first, leaving an undesirable residue, while the heavier constituents are likely to condense when brought in contact with cool walls for some length of time.

At the higher pressures the boiling temperatures of all hydrocarbons and their mixtures are shifted higher up, as can be seen in Fig. 5. This is of importance for the evaporation of oils within the combustion chamber of heat engines. The curve for American petroleum is especially remarkable in that it shows that the boiling temperatures of *mixtures* increase with the rising pressures at a faster rate, what is easily understood from curves in Figs. 2, 3 and 4. It shows further that at a temperature of 400 degrees Centigrade decomposition of the petroleum takes place, and oil gas is formed. The provocation of this process is almost independent of the pressure. It has not been classified yet which role this transformation of the liquid fuel into oil gas—which with all motor-fuel oils appears to take place between 400 and 500 degrees Centigrade—plays during the inflammation and combustion of the dynamic mixture in the cylinder.

Proportion of Air Necessary for Combustion

Fig. 6 gives another graphic presentation of the hydrocarbons of the paraffin series, with their respective vapor volumes. They are arranged in succession according to their boiling points, but on a different scale from that which was used

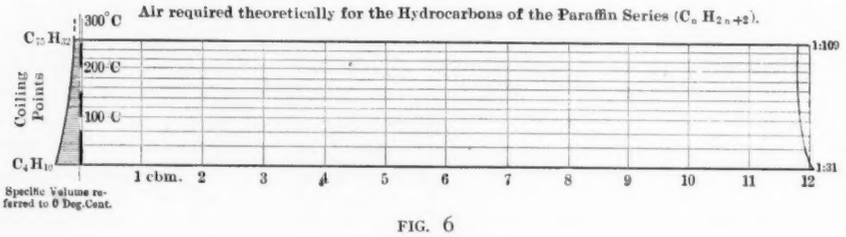
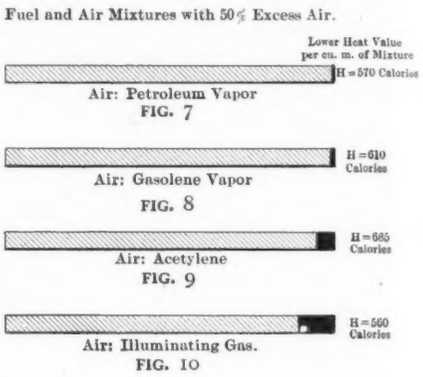

Air required theoretically for the Hydrocarbons of the Paraffin Series ($C_n H_{2n+2}$).
300° C
$C_{15} H_{32}$
200 C
Coiling Points
100 C
$C_4 H_{10}$
1:109
1:31
1 cbm. 2 3 4 5 6 7 8 9 10 11 12
Specific Volume referred to 0 Deg. Cent.

FIG. 6

before. The table shows the smallest quantity of air which is theoretically required to secure perfect combustion under the various conditions outlined. The volumes are again referred to zero Centigrade. They must, therefore, be assumed correspondingly larger at the higher temperatures. From this table, among other things, we recognize the fact that the higher the boiling point of an oil the smaller is the volume of its vapor per unit of weight. This refers as well to the volume proper, or the absolute volume of the oil vapor, as to its proportion to the air which is necessary for combustion. Thus, while gasolene requires an air volume, of equal temperature, about 40 times larger than its vapor volume, a heavy petroleum requires a volume of air at least 100 times as large. Together with



the larger quantity of air required the diffusion property of the vapor, that is, its capability of mixing with air, is reduced since the vapor grows heavier and less mobile. For instance, $C_{15} H_{32}$ vapor is produced from the liquid at 260 degrees Centigrade, and is eight times heavier than air of the same temperature.

In order that every single molecule of such a vapor may find its corresponding 100 molecules of air, which are required for perfect combustion, a very intimate mixture of the two charge constituents must be effected. Unless the mixing process is properly executed the lighter volatiles, which require less air, will inflame first, while the heavier constituents will burn later and imperfectly, forming CO_2 and soot, etc., and leaving behind tarry and other undesirable residues. In practice a way out of this difficulty consists in using with oils of high boiling points a surplus of air of at least 50 per cent. As a matter of fact, the secret of the extremely high economy of some oil engines that have come under the observation of the writer is that a liberal supply of air was provided, especially when using crude Texas and similar oils. It seems a simple matter, at first sight, to have an excess of air in an oil engine. Yet it will be shown later that only with certain types of engines, and with proper timing and proportioning of the air in the mixture, can the thermal gain due to the higher combustion efficiency of the mixture be realized without entailing greater losses in economic efficiency, owing to more costly and more complex mechanism and greater negative pump work.

Figs. 7, 8, 9 and 10 give a graphic presentation of the proportion of combusti-

bles to air with various fuels, namely, petroleum vapor, gasolene vapor, acetylene, and illuminating gas, all with 50 per cent. excess air. When we remember how difficult it is to produce a perfect mixture even between illuminating gas and air, especially in larger engines, and how easily the burner of an acetylene-gas flame gets sooty when a little excess gas escapes, and moreover, when we consider that the smell of the exhaust gases of almost every automobile motor is indicative of the imperfect mixture of the combustible oil gases with air, then it will be understood that even greater difficulties accompany the successful application of crude oils and such of high boiling

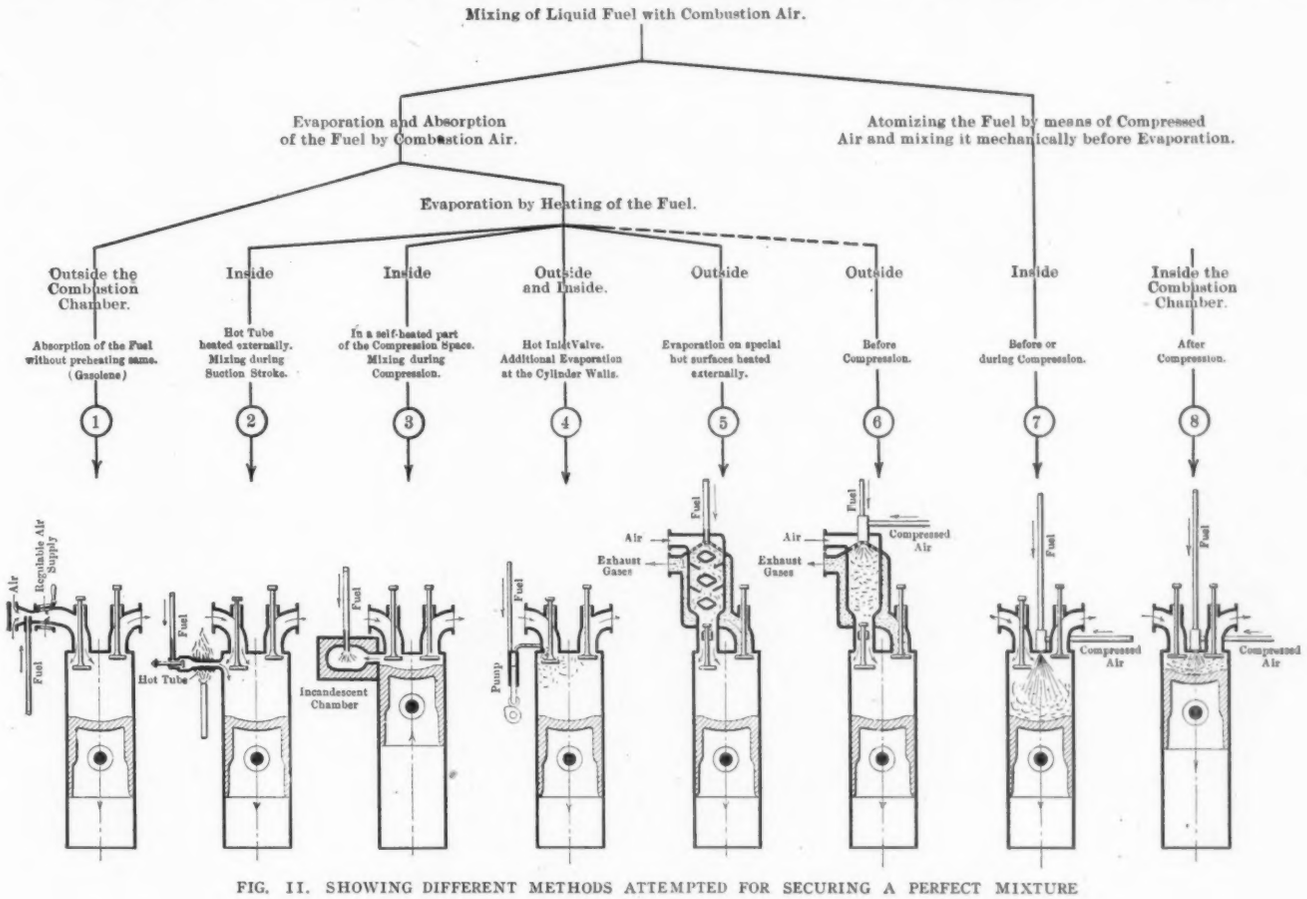


FIG. 11. SHOWING DIFFERENT METHODS ATTEMPTED FOR SECURING A PERFECT MIXTURE

points in internal-combustion engines of considerable size.

Various Methods of Securing Proper Mixtures

Fig. 11 is an attempt to combine the different solutions which have been attempted for securing a perfect mixture, in form of a system which gives, at the same time, a survey over the various types of engines as constructed at present. Of course, the limits or distinctions between the different modes and forms of application are in reality not quite so rigidly drawn as here shown.

There are two principal methods for obtaining a good mixture. The one aims at the evaporation of the fuel before and during the mixing process proper, the latter process being performed partly by mechanical means and partly through the absorption of the vapor or spray by the air. Depending on the kind of fuel used it is necessary to preheat the air more or less before it is used for vaporizing the liquid. The other method aims at an intimate mechanical mixture of the liquid fuel with air before vaporization is commenced. Therefore, the oil is introduced uniformly and in a finely atomized spray into the air which serves to support combustion, so that every drop of oil tends to evaporate separately. The best and perhaps only available means for producing a perfect "oil mist," or vapor, consists in employing some kind of compressed gas, either air or steam, for atomizing purposes. Such air or steam will carry the smallest drops or particles straight into the surrounding air, and in expanding will burst the small bubbles, thereby promoting an intimate mixture of the two charge constituents.

This is a short explanation of the various schemes shown in the drawing: Solution No. 1 shows the device that is most often used in ordinary gasolene engines. Air is aspirated from the atmosphere and draws the liquid fuel from the carbureter jet and absorbs it. No preheating of the fuel is required, but in order to prevent rapid cooling of the whole apparatus in consequence of the evaporation process, the aspirated air is usually preheated. For slowly evaporating liquid fuels the scheme is applicable only when ample provisions are made to preheat the air; or else the fuel must be preheated either previous to its entering the engine or in the engine itself. Solution No. 2 shows a device which was largely used in the earlier days, namely, a hot or incandescent tube serving to inflame the mixture of oil vapor and air at the end of the compression stroke, at the same time acting as a vaporizer for the liquid fuel. The mixing is performed during the aspiration period, and is therefore necessarily insufficient. A better way is the one followed by Hornsby and shown in No. 3. The oil is injected into an incandescent hood or chamber which is kept hot by the combustion in it of the mixture. During the compression stroke air from the cylinder enters into this chamber in form of a thin stream and mixes with the vapors generated therein until the right proportion of combustible to air is reached. This mixture is heated partly by compression and partly by direct contact and radiation from the incandescent walls of the chamber until self-ignition sets in. This is an excellent device for the smaller sizes of motors, and has found extensive adoption in different countries. In most of the engines a special oil-pump serves to inject the oil into the incandescent chamber, though it would obviously be better to inject and spray it by means of compressed air delivered by a separate air pump. The latter construction has

been adopted by the writer with excellent economic results.. In some engines like the Priestmann, the Banki, etc., water is injected together with the fuel with more or less success. It is impossible here to dwell on the deficiencies of such practice in detail, but it may be said that only when the time of injection and quantity of water injected are very accurately determined and regulated is the thermal gain greater than the combined thermal and mechanical losses.

Solution No. 4 shows a device in which petroleum is injected by means of a pump during the aspiration stroke, and is thrown against heated walls or surfaces, as, for instance, against the hot disk of the inlet valve, where it evaporates and is distributed, together with the air, throughout the cylinder. The whole of the aspiration and compression strokes is available for evaporation and diffusion. A combination of Nos. 1 and 4 is employed in the Deutz motors, of Cologne, but its use is limited to the lighter oils only. For heavier oils a more complete evaporation is required, such as is shown for instance in No. 5. With this arrangement a thorough preheating of the combustion air is necessary in order that complete absorption of the oil vapors by the air may take place. Such preheating decreases, unfortunately, the volume of air aspirated and therefore the capacity output of the engine.

Two Comparatively Successful Methods

At an earlier occasion I have discussed the experiments made by Petreano to determine the effect of premixing on the combustion efficiency of gas and oil engines. The arrangement No. 5, as employed by Dürr and others, is quite similar to that used by Petreano. When the vaporizing chamber attains very high temperatures oil gas is formed and residues settle down on the walls, which is, of course, a disadvantage. When compressed air instead of free air is employed for the vaporization of the fuel, the result is solution No. 6, which is very similar to No. 5. There is a hot chamber heated externally by exhaust gases, the chamber serving to evaporate at once those drops of the liquid fuel which are thrown against the walls, thereby positively avoiding the formation of residues. This process has been successfully employed by Priestman and Griffin, in England.

In scheme No. 7 the oil is atomized by means of compressed air and is vaporized in the engine cylinder, either during the suction stroke or during the compression stroke, or both. An engine working along these lines was built by the writer some time ago, and in a series of tests made by Cornell University it has shown such highly satisfactory results in regularity of running and economy of operation that its presentation as a standard mechanism would seem justified. However, the writer prefers to publish later a detailed description of the working process and of the results attained. Scheme No. 8 provides for the atomizing and vaporization of the liquid fuel at the end of the compression stroke and within a very small space. Though the time available for diffusion is very small, yet the mixture is of uniform composition and well proportioned. This process was originally employed by Söhnlein in the year 1884. Söhnlein deserves the credit of having invented, also, the small two-stroke-cycle type of motor which is now so extensively used all over the world. Later, in 1893, the same process was employed in the Diesel oil engine, which now holds an undisputed first rank in economic distinction, at least on the European continent.

While it is unavoidable when the vapor is formed before the end of the compression stroke that a small portion of the vapor particles condense to liquid drops in contact with the cylinder walls, this action cannot take place in scheme No. 8, since the oil particles are burned immediately after their mixture with air, and cannot, therefore, proceed to the walls in liquefied state. Haselwander and Trinkler are using this system in their engines.

After this brief survey of the existing constructions Kutzbach arrives at the following résumé: For fuels with low boiling points all schemes from 1 to 8 are applicable; for heavy oils only No. 3 and Nos. 5 to 8 can be used, and of these No. 8 possesses the advantage over all others that a contact of the oil vapor with the cool cylinder walls is positively avoided.

Catechism of Electricity—XXVII

Portable Alternating-current Ammeters

532. *Are not the working parts of portable alternating-current ammeters designed along the same lines as the portable alternating-current voltmeters previously taken up?*

Some are and some are not.

533. *Mention some common forms of portable alternating-current ammeters that differ in design from the instruments previously considered.*

Two of the most common and accurate alternating-current ammeters are the Siemens dynamometer and the Kelvin balance. The Siemens dynamometer is shown by Fig. 132, and the principle of its operation is illustrated by Fig. 133. The main parts of the instrument are two coils represented by the wires $a\,a'$ and $b\,b'$, at right angles to each other, the coil $a\,a'$ being stationary and, as shown in Fig. 132, bound securely to the support d by the band e. It is composed of many more turns than the coil $b\,b'$, which is the "movable coil," being suspended on a steel pivot which rests in an agate cup and is free to move about its vertical axis. The current to be measured passes through the two coils in series, and the movable coil tends to turn so as to place its plane parallel to the plane of the fixed coil, in order that the lines of force produced by the two coils may coincide in direction. This tendency of the movable coil to turn about its vertical axis is counterbalanced by the force of the spring t, one end of which is adjustable by hand by means of the knob z. Permanently attached to the knob z is the pointer p, which indicates by its position above a graduated scale s, Fig. 132, the number of degrees through which the end of the spring has been adjusted.

In Fig. 132 part of the top of the glass case and a section of the brass rim have been broken away to show the scale, pointer and index. The index q permanently attached to the movable coil indicates zero on the scale s when the plane

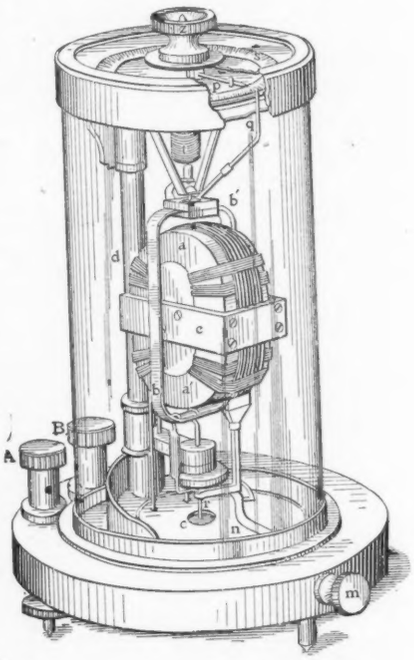


FIG. 132. SIEMENS DYNAMOMETER

of the movable coil is at right angles to that of the fixed one.

534. *Explain the method of measuring a current on the Siemens dynamometer.*

First, the knob z should be turned so that the pointer p indicates zero. If the index q is not then at zero, the instrument is not level, and the adjustable screws on which the instrument rests must be turned until the index q is at zero, care being taken that the rod r, Fig. 132, which forms one terminal of the movable coil, and makes contact with the fixed coil in the mercury cup c, hangs centrally in the cup. Having made this adjustment and connected the binding posts A and B in series with the circuit, current passes through the coils; the movable coil will no longer remain at right angles to the fixed coil, but will turn about it, thus carrying the index q off the zero point. The knob z should

then be turned until the index *q* again points to zero. When this occurs the pointer *p* will be found to have been turned through a certain angle indicated by the number of degrees on the scale.

535. *What relation is there between this angle and the current passing?*

The force of torsion or twist is proportional to the angle of torsion. As the angle through which the screw is turned in order to keep the movable coil at zero is an exact measure of the torsion applied, the force necessary to produce that angle must be proportional to the force acting between the two coils and due to the current circulating through them. This force varies as the square of the current strength, so that the current strength is proportional to the square root of the angle of torsion.

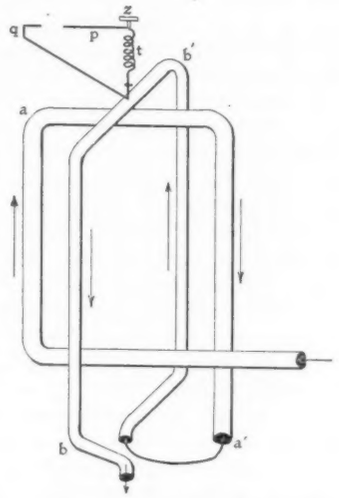


FIG. 133. ILLUSTRATING THE PRINCIPLE OF THE SIEMENS DYNAMOMETER

The best method for determining the current for a given angle is to use a calibration curve, which is furnished by the makers of the instrument, and is drawn when the instrument is being standardized, and which shows directly the current corresponding to each number of degrees on the scale.

536. *What are the advantages and disadvantages of the Siemens dynamometer for measuring currents?*

Accurate results can be secured in measuring both direct and alternating currents, and these results are independent of the frequency and form of the alternating current. Having no iron or permanent magnets, the constancy of the meter depends upon the spring *t*, which experience shows does not change from year to year.

The instrument, however, must be kept carefully leveled and free from outside magnetic influences. Not being a direct-reading instrument, some time is required for obtaining a reading, and the dynamometer is therefore of little use when the current fluctuates rapidly. Whenever it is necessary to move the instrument, the screw *m* must be turned. This raises the movable coil by raising the arm *n*, and holds it firmly in place, thus preventing any injury to the suspension system.

537. *What are the usual sizes in which Siemens dynamometers are made?*

They are made in 20, 60, 200, and 500 amperes capacity.

538. *Explain the operation of the Kelvin balance.*

The Kelvin balance depends for action upon the force either of attraction or repulsion, exerted between adjacent portions of one or more electrical circuits. In order that this force shall make itself evident and be measurable, it is of course necessary that one portion of the circuit be movable. As suggested by the name, the movable part takes the form of a balance arm supporting at each end a coil of wire, as shown at *a* and *b* in Fig. 134, which represents a diagram of the balance. The balance arm is forced upward or downward by the action of the stationary coils *c* and *d*, *e* and *f*. The movement of the balance arm is opposed by weights, which are placed in a carriage represented at *u* Fig. 135, where a perspective view of the instrument is shown. Hence, by adjusting the weights and the position of the carriage *u* along the balance arm *m n*, a certain position of the carriage may be found where equality exists between the force exerted by the electric current and the opposing force of gravity; this equality being attained when the pointer *p* at each end of the balance indicates zero.

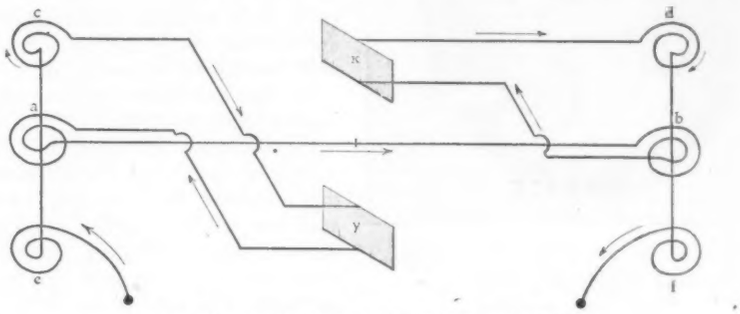


FIG. 134. DIAGRAM OF THE KELVIN BALANCE

The various coils are wound with coarse or fine wire, according to the range or use of the instrument, and the movable coils *a* and *b* are connected so as to produce opposite polarities on their upper faces; one having a north pole uppermost, the other a south pole uppermost. This produces an "astatic" system, so that the meter is not affected by the earth's field nor by nearby magnetic fields, providing the instrument is placed in such position or at such a distance as to render the nearby field practically uniform in its effect on the movable coils. The stationary coils are so connected as to act together in forcing the balance arm one way or the other.

The balance arm is supported at its center by two trunnions indicated in Fig. 134 by *x* and *y*. These trunnions have each an elastic ligament of fine wire through which the current passes into and out of the circuit of the movable coils. If the ligaments become stretched after the instrument is standardized, the index at one end of the balance arm will be found to be below the middle line on the vertical scale when the index at the other end is pointing at zero. The error so introduced will be a small one, but may be eliminated by loosening the screws and adjusting the scales so that the difference between the zero point on the scale and the position of the pointer is equally divided on both sides.

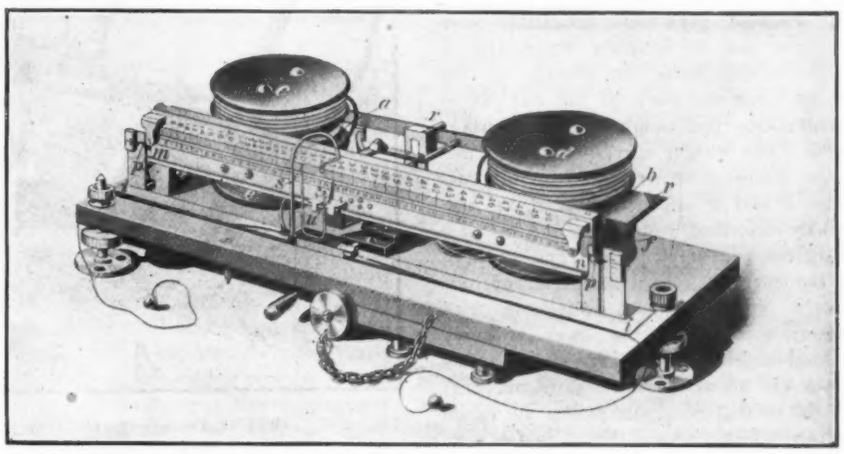


FIG. 135. THE KELVIN BALANCE

539. *Can the range of the Kelvin balance be increased by the use of weights?*

Yes; each balance is provided with four pairs of weights for this purpose, of which the carriage *u*, Fig. 135, and its counterpoise placed in the trough *r* at the end of the balance arm constitute the first pair. The carriage slides on an approximately horizontal graduated arm *m n*, attached to the balance arm. The apparatus

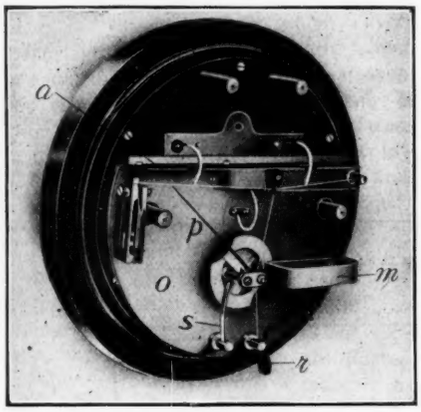


FIG. 136. A STATION ALTERNATING-CURRENT AMMETER OF THE HOT-WIRE TYPE, WITH CASE REMOVED

shown at *s* is used to move the carriage *u*, and consists of a slider, one arm of which projects upward between the projecting arms of the carriage. By means of an attachment to the curved arm of the slider, it is possible to cause a very small movement of the carriage. The slider is moved along the guide *i i* by means of the cords attached to both ends. By this arrangement an adjustment of the carriage is easily made by hand, even when a glass case is placed over the working parts.

When the range of the instrument is to be increased over that obtainable with the first pair of weights mentioned, a larger counterpoise is placed in the trough *r* in the place of the one corresponding to the weight of the carriage alone. The weight corresponding to this larger counterpoise is placed on the carriage *u* and a balance obtained, as previously described, by moving the carriage along the graduated scale. The strength of the current is then read off approximately on the upper scale, or with greater accuracy on the lower or finely divided scale. The weights and counterpoises are adjusted in the ratio of 1: 4: 16: 64, so that each pair makes the range of the balance double that of the next lighter weight and counterpoise.

540. *In what sizes are the Kelvin balances made?*

They are made of $\frac{1}{100}$ to 1 ampere capacity; $\frac{1}{10}$ to 10 amperes, 1 to 100 amperes, 6 to 600 amperes, and 25 to 2500 amperes capacity. These balances are designed to carry their maximum current sufficiently long for taking a reading, and 75 per cent. of this current continuously.

541. *What advantage, if any, does the Kelvin balance possess over the Siemens dynamometer?*

The Kelvin balance is a much more accurate instrument; in fact, it is the most accurate of all instruments for measuring alternating currents and is frequently used as a standard in the calibration of other ammeters. It is also a direct-reading instrument, whereas the Siemens dynamometer is not, and is equally well adapted to the measurement of both direct and alternating currents.

542. *Mention any precautions that should be observed in the use of the Kelvin balance.*

For the most accurate results a glass case should be placed over the working parts while taking a measurement, in order that air currents may not affect the movement of the balance arm.

To insure accurate observations either when reading the position of the carriage or in adjusting the zero position, use should be made of the lens provided for this purpose. The vibrations of the balance arm may be checked so as to facilitate reading, by bringing the slider arm, which moves the carriage, lightly in contact with it in such a way as to produce a little friction without moving the carriage.

Station Alternating-current Ammeters

543. *Upon what principles does the action of station alternating-current ammeters depend?*

The usual types of these meters depend for their operation upon the same principles made use of in the portable alternating-current voltmeters already explained. There are, therefore, station alternating-current ammeters operating by reason of the mutual magnetic attraction between two coils through which the current is led, between an inclined coil and a vane, or by reason of the variation in length of a wire due to the heat produced by the current passing through it.

544. *Illustrate and describe one of these types of station alternating-current meters.*

Fig. 136 shows a hot-wire alternating-current ammeter for station work, with case removed. The wire which becomes heated by the current and elongates, allowing a spring to move the pointer *p*, is shown at *a*. It is made of platinum-silver, about six inches long, and is stretched between the two terminals of the meter. Silver strips furnish auxiliary connections to the hot wire *a*, enabling current to reach the wire through several parallel paths. Near the center of the hot wire is fastened another wire *e*, made of phosphor bronze, which runs to a terminal *c* at the bottom of the instrument. Branching from this phosphor-bronze wire is a strong fiber, which is looped around the jewel-mounted steel drum carrying the pointer, and terminates in the spring *s*, which keeps it taut. When a wire is stretched nearly straight between two points, the slightest change in its length causes a considerable change in the amount of slack. Accordingly, when current passes through the platinum-silver wire *a*, its consequent elongation produces a considerable slack in the phosphor-bronze wire *e* and this slack is immediately taken up by the tension of the steel spring *s* on the fiber, the drum around which the fiber is looped being thereby rotated in proportion to the slack taken up. A very slight change in the length of the hot wire, therefore, rotates the drum through a considerable angle, and a scale of the usual dimensions is obtained with a pointer of the usual length.

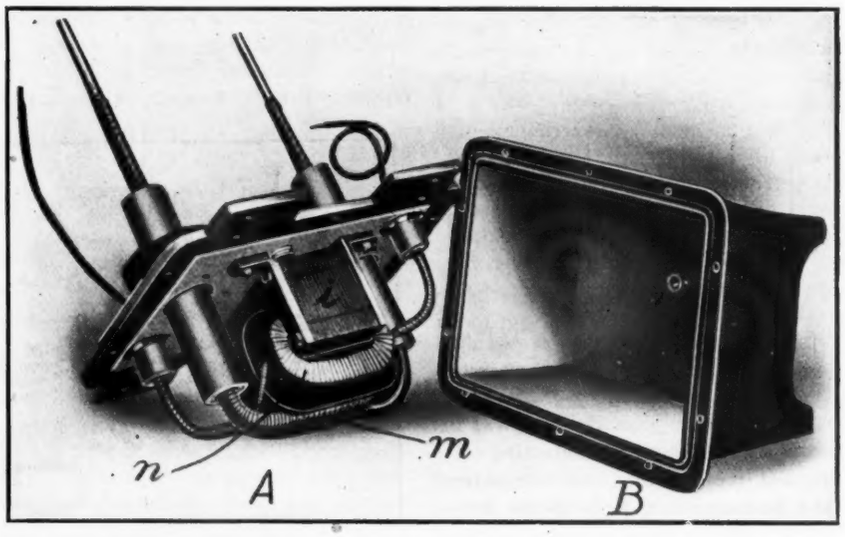


FIG. 137. CURRENT TRANSFORMER USED WITH ALTERNATING-CURRENT AMMETERS FOR MEASURING CURRENTS ON EXTRA HIGH POTENTIAL CIRCUITS

The working parts are mounted on a plate *o*, made from an alloy having a temperature coefficient the same as that of the measuring wire so that the accuracy of the instrument is unaffected by external temperature changes. The damping mag-

net shown at *m* is used to make the meter dead-beat. A short-circuiting switch, the handle of which can be seen at *r*, is provided to relieve the hot wire of the current when it is not desired to take readings. The zero adjustment is made, when no current is flowing, by means of a small hard-rubber thumb-screw projecting from the side of the meter.

545. *Are ammeter shunts used with hot-wire station ammeters?*

Yes, except in special instruments designed for very low currents or for circuits carrying over 3000 volts. In some cases several shunts are provided for the same meter, so that it can be used for widely different currents. The meter dial is then marked with several scales, or, when the shunts are of a convenient ratio, the proper scale can be provided for one shunt and the readings multiplied or divided, as the case may be, when other shunts are used.

546. *What provision is made for measuring current on a circuit carrying over 3000 volts pressure?*

A series transformer is used in place of an ammeter shunt.

547. *What is a series transformer?*

It is a transformer constructed similarly to a potential transformer but designed to be connected in series with the main circuit instead of across it. Its function is to transform the current rather than the voltage, and for this reason it is often called a current transformer.

A series or current transformer used in connection with the hot-wire station ammeter is shown in Fig. 137, the working parts at *A* and the iron case at *B*. Oil is used in the case to carry away the heat from the coils *m* and *n*, the former of which is the primary to be connected in series with the main circuit, and the latter the secondary, to be connected in series with the meter. The laminated iron core around which both coils are wound is shown at *i*. This type of transformer can be used on voltages up to 30,000, with currents up to 200 amperes, and will give a secondary current up to 3 amperes, this latter being the maximum current which the hot wire in the meter is designed to carry.

Flue-gas Analysis: Its Value

By Joseph W. Hays

Much is being said and written about flue-gas analysis, and automatic instruments for the analysis of gases have recently appeared upon the market. The manufacturers of these instruments are most persistent advertisers, and in consequence the subject, like the ghost of Banquo, will not "down." It will be satisfied with nothing less than a prominent place in the "amen corner" of the sanctuary of boiler-room economics. The prominence with which the matter is being brought before the engineering eye causes an inquiry into the real economic value of gas analysis to be charged with particular pertinence at this time. As the value of it is overestimated in some quarters and underestimated in others, the inquiry assumes even more importance.

The impression is too widely prevalent that a machine for analysis and a hole in the breeching for a sampling pipe are all the equipment an engineer requires to render him expert in the regulation of the furnace fires. Of what value is an indicator diagram, if the engineer is unable to read it? Of what value is the chart from a CO_2 recorder, if the engineer is unable to interpret it correctly? To tap the gas passages at any point, such as the breeching, and find any given percentage of CO_2 (4 per cent., for instance) does not necessarily indicate anything as to furnace performance. Correctly interpreted, the results from an analysis of the escaping flue gases may be of the highest value to the engineer. It is only by such analysis that the highest economy in furnace operation may be attained and maintained.

Underestimation of the value of gas analysis can in most cases be traced to either ignorance or prejudice. Gas-analysis apparatus has entered the boiler room to stay, and arguments *pro* and *con* as to its right to be in that domain are always one-sided. I shall make no effort to convert the underestimators; the progress of events will do that for us. It is of vastly more importance to consider the errors of overestimation.

To increase furnace efficiency is the sole aim and end of flue-gas analysis. It is not concerned with any other consideration.

What is the true criterion of furnace efficiency?

That furnace is the most efficient which accomplishes complete combustion with the least surplus of air.

When a quantity of air just sufficient for the operations of combustion is permitted to enter the furnace, efficiency will be at the highest point attainable. If the air supply is decreased, combustion will be incomplete. Unutilized heat units will go up the chimney. If the air supply is increased, the excess air will cool the furnace by the absorption of heat units, and energy that might otherwise express itself at the piston of the engine will be wasted upon the atmosphere. Every engineer recognizes these facts, or ought to.

Exactness versus "Dead Reckoning"

There are two ways by which the mariner may locate his position upon the trackless ocean. One is by "dead reckoning," which may give him anywhere within a thousand miles of his true location. The other is by observation with astronomical instruments, which locates his ship with exactness. The engineer who is not equipped for flue-gas analysis must rely perforce upon "dead reckoning." How far he is from the true position of efficiency will never be discovered until he knows the make-up of his chimney gases. No squinting at the steam gage and fiddling at the dampers will ever enable him to determine how near or how far he may be from the hair line of highest furnace efficiency.

Oxygen constitutes about 21 per cent. of the air by volume. If carbon should be burned with only the theoretical quantity of air, all of the oxygen would unite with carbon, and we should have 21 per cent. of carbonic-acid gas, or CO_2, in the escaping chimney gases. As some surplus air is necessary in actual furnace operation, owing to the difficulty of securing a prompt and thorough mixture of the admitted air with the combustible furnace gases, we are forced to be satisfied with a maximum of from 15 to 17 per cent. CO_2 and a minimum of from 4 to 6 per cent. free oxygen. Anything short of these figures represents something less than possible attainment. When all the exigencies connected with boiler-furnace operation are considered, an average for the day's run of 12 per cent. CO_2 may be counted very satisfactory. The average steam plant will be unable to show in excess of 7 per cent. This is the efficiency of "dead reckoning."

With a proper instrument for gas analysis correctly operated and the findings understandingly interpreted, 12 per cent. CO_2 can be easily attained. The difference in economy between 12 per cent. and 7 per cent. is around 11 per cent. in fuel. This statement is based upon the assumption that the findings for CO_2 actually express the conditions of furnace operation. A low percentage of CO_2 may be due to one of two causes: First, excess of air or steam, diluting the gases; second, deficiency of air and incomplete combustion, resulting in the presence of carbonic oxide and hydrocarbons in the furnace gases. Either cause will bring down the percentage of CO_2 and a waste of fuel will occur, for the reasons already noted. It is most important to determine, before undertaking furnace regulation, to which of these causes the low percentage of carbonic-acid gas is chargeable.

Importance of Oxygen Determination

It is most unfortunate that builders of automatic instruments for furnace-gas analysis have so riveted their eyes upon the CO_2 that the importance of oxygen determination has completely escaped them. In my poor opinion it is more important to know the percentage of oxygen than that of carbonic-acid gas. Oxygen is the cause, the other elements represent the effect. If the oxygen content is what it should be, the proper amount of CO_2 will usually be found in company. The CO_2 recorder determines carbonic-acid gas for the purpose of inferentially arriving at a

conclusion with respect to oxygen. The inference, which is often wrong, might be avoided if oxygen were directly determined.

The ideal apparatus will determine and record both CO_2 and oxygen. The sum of the percentages of these two gases should approximate 21; if less than 21, the difference may be assumed as due to the presence of carbonic oxide and other combustibles. Such a state of affairs requires either more oxygen or better admixture of the oxygen with the combustible gases. The percentage of oxygen carried, as indicated by the chart which accompanies such apparatus, will enable the engineer to determine at once which is the case. If the oxygen exceeds by about 5 per cent., the fault is due to lack of mixture, if it is less than 5 per cent., the fault is due to lack of oxygen.

The single-analysis machine, that is, the apparatus analyzing for and recording only CO_2, registers the complaint that *something* is wrong. Such a machine puts it "up to" the engineer to discover *what* is wrong.

The compound-analysis machine, that is, the machine analyzing for and recording both CO_2 and oxygen, when someone produces it, will not only indicate trouble but tell the engineer where the trouble lies, whether it is due to excess or deficiency of air, or the lack of proper admixture with the combustible furnace gases.

No gas-analysis apparatus, whether single or compound will ever entirely eliminate the factor of human judgment. Let us assume the case of a low percentage of CO_2, indisputably due to an excess of air. What is the first step to be taken by way of correcting the difficulty? The natural answer is, "reduce the quantity of air supplied to the furnace." This apparently obvious answer is entirely wrong. Here is where the factor of human judgment enters into the equation. First locate the source and cause of the excess air. The excess air discovered may be assisting us on the road to economy, rather than acting as a hindrance.

Results of Air Leakage

Circumstances connected with a case which recently came under my own observation may serve to clear up the above apparently anomalous statements. The standard Orsat gas-analysis apparatus was employed in this instance. The boiler was of the horizontal water-tube type, with horizontal baffles. Gas samples for analysis were drawn from the breeching at a point just forward of the damper. A number of analyses were made, showing an average of slightly under 3 per cent. CO_2. The oxygen was determined and found to be slightly in excess of 17 per cent. The damper was then checked until the engineer called for steam. The CO_2 stubbornly refused to rise above 5½ per cent. Here was a puzzling proposition, and the prospect of raising the CO_2 to 12 or 14 per cent. looked hazy.

The gas-sampling pipe was next introduced into the first pass near the rear of the boiler; the result was 9 per cent. CO_2. The course of the gases was then followed toward the breeching, and from 8 to 9 per cent. CO_2 discovered, the quantity appearing to diminish gradually as the breeching was approached, which I attributed to leakage through the walls of the setting. Samples were then taken from just forward of the breeching damper, as in the beginning, with the result of about 3 per cent. CO_2. The evidence conclusively pointed to a leakage of air into the breeching; examination developed such a leak of large proportions. A strong current of air, of course, was entering the breeching and diluting the gases. The leak was stopped and the following results were noted:

The draft increased 3/10 of an inch, due to temperature rise in the breeching and stack; CO_2 rose in the breeching to 5 per cent., and dropped in the gas passages of the boiler to 6 per cent. Economy considered, we were now worse off than in the beginning. The air that formerly entered by the leak in the breeching was now being pulled through the furnace. It was ravenously devouring and carrying away heat units. The dampers were then checked, when there was plenty of steam and the CO_2 was raised to about 12 per cent.

It makes a great deal of difference where the dilution is occurring. If in the breeching or at any other point beyond the heating surfaces of the boiler, such dilution may be an actual benefit, as the tendency in most plants is to operate under too much draft. The dampers might as well not be in existence for all the use that is ordinarily made of them. Surplus air is a harmful influence, in proportion to the distance it travels between the front of the furnace and the point where the gases leave the heating surfaces of the boiler.

If flue-gas analysis is contemplated as a test of economy, the location of all air leaks should be the first concern of the engineer. Until this has been done, it cannot be assumed that any analyses of gas taken from the breeching are indicative of the real conditions of furnace performance.

I regard the present movement toward gas analysis as the most important occurrence since the search for economies was first instituted in the boiler room. Gas analysis is the only conclusive test of furnace efficiency, but like every other form of test care must be taken to eliminate all possible causes of erroneous conclusions.

The output of German coal for the first four months of 1907 was 46,087,753 metric tons, an increase of 1,528,039 tons, 18,285,781 tons of lignite, 6,428,148 tons of coke, and 4,686,618 tons of briquets.

Compressed Air and the Kinetic Theory of Gases

By J. H. Hart

To the ordinary consumer of compressed air it serves simply the purpose of an energy reservoir and for power transmission. Its utilization in this field is so efficient and is so easily obtainable that it is doubtful if it will ever be replaced by any other material. In reality, however, the general viewpoint of compressed air as an energy reservoir is fallacious—compressed air contains no more energy than ordinary air. This is doubtless a matter of considerable surprise to most engineers and consumers in this field, but there is no doubt that it is essentially the truth.

In order to understand this statement and see how compressed air utilizes energy a complete study of the kinetic theory of gases would be essential. In fact, no thorough knowledge of compressed air in any form is complete without a knowledge of its connection in this field. Compressed air is simply air which has been compressed to a higher pressure and the laws which govern it are simply those which hold throughout in the kinetic theory of gases. According to this theory, a gas is made up of individual molecules flying around through space like small projectiles, colliding and re-colliding with each other and with the walls of containing vessels. The summation of this series of blows on a surface constitutes what is known as pressure. The real meaning of temperature is absolutely unknown, but it is known that absolute temperature today is directly proportional to the mean kinetic energy of these small projectiles or molecules. Now, in order to understand variations in pressure, temperature and volume, a complete knowledge of the relations of these projectiles to each other and the transfer of energy between them is absolutely essential, and a study of this phenomenon is what is known as the kinetic theory of gases.

To show that the first statement in regard to compressed air as an energy reservoir is true, all we need to consider is the fact that the temperature, if not identical with, is at least proportional to, the energy of the molecule. When a gas is compressed the molecules are given an increased amount of kinetic energy. This means that they are raised in temperature by compression. If the gas now under pressure is allowed to cool off to normal temperatures it thereby loses the energy which has been put into it and which has become apparent as an increase in temperature. Each molecule possesses precisely the same kinetic energy as before compression and in a gas, unless extreme compression is accomplished, the molecules still remain at a distance sufficiently apart to have no influence on each other.

Hence the total kinetic energy in the gas under compression is identical with the total kinetic energy in the gas before compression. Of course, the energy has been concentrated in amount per cubic foot, but if this gas were allowed to expand in a cylinder without access to the outside air, or, rather, without thermal connection with surrounding bodies, little or no work could be obtained from it.

Compressed Air Merely Transforms Energy

In reality, a gas under pressure, when it starts to expand, loses some of its energy to the piston. It then possesses a smaller amount of mean kinetic energy per molecule and is, therefore, at a lower temperature. It is immediately raised by the surrounding atmosphere, or containing vessel, to normal temperature and can then continue doing work at this higher pressure, and the process continues until the pressures on both sides of the piston become equal. From this it is evident that compressed air is not a reservoir of energy in any form; it is merely a transformer of energy which has been put first into the compressed air, and lost from that into the atmosphere, from which it is taken back when it is desired to be utilized. This is a rather new conception of compressed air for most engineers, but there is no doubt at all that it is a correct statement of actual conditions. Compressed air expanded freely into a vacuum does absolutely no work and does not cool off or lose energy. In reality, the compression of air means, from the thermodynamic viewpoint, an increase in its entropy.

This becomes evident when the compression on a pressure-volume diagram is considered. Every engineer knows that the curve which represents adiabatic compression is steeper than the curve representing isothermal compression. An adiabatic curve is synonymous with what is known as an "isotropic" curve, and this latter name is quite as generally used. An isotropic line is a line of constant entropy, and going from one isotropic line in the pressure-volume diagram to another means a change in the entropy. Now most compression is adiabatic, if at all rapid. Of course, the object in compression is to get the curve as near isothermal as possible in order to diminish the amount of work necessary to produce the compression. Hence, we have three-stage compressors in which the gas is compressed adiabatically, then cooled off to the temperature that it would have had if compressed isothermally, and the process repeated twice, giving three stages. This results in an increased efficiency of production, but since the processes are identical in action only one—that of the single-stage compressor—need be considered. In this the compression is generally adiabatic, then the curve drops vertically to the isothermal point as the gas cools off and the pressure diminishes on this account without change in volume. At this point in the diagram, however, the gas has reached another adiabatic curve passing through this point so that the total change in the gas is in reality simply a change in pressure, volume and entropy, whatever the latter may mean.

The conception of entropy while extremely clear in some respects, is too complicated for the ordinary engineering mind and need not be considered in regard to its nature. Every body in the universe possesses entropy to a greater or less extent and it is as general a property of matter as temperature, pressure, volume, density, or resistance. We have no efficient means of measuring this property of matter and hence we are not familiar with its manifestations and changes. Sufficient, however, to say that it has a complete conception, and a comparatively clear one, to thermodynamic students, and that it has aided much in the understanding of the changes which occur in substances whenever transference of energy takes place.

Kinetic Theory Clears Up Complex Points

There is no doubt that a capable treatment of the subject of compressed air from the standpoint of the kinetic theory of gases elucidates many complex points and renders clear much that is otherwise obscure. This conception of the energy in compressed air explains clearly the inability to utilize it in free expansion. In the transference of energy from place to place, through long pipes, this is carried on by a series of bombardments from molecule to molecule and explains the time taken in transmission and the loss of energy, or the diminution in pressure, which results when the transmission is long. It enables the engineer to understand clearly what occurs in compression and what is meant by the different kinds of compression. Thus, adiabatic compression means compression in which heat as such does not pass to or from the air or gas in the containing vessel. Every time molecules are hit by the piston they are forced to rebound and given an increased energy. This energy is not lost in adiabatic expansion to the walls of the containing vessels, but is present when the molecules collide with the piston a second time. It explains by this reasoning the manner in which the pressure rises abnormally over that in isothermal compression.

In this latter the molecules rebound from the piston with an access of energy, but this is lost by transmission to the walls of the containing vessel before they collide again; hence the pressure does not rise abnormally over what it should theoretically be. In this respect the pressure depends simply on the force with which each molecule strikes, the number of times it strikes a second, and the number of molecules which hit per square inch of surface.

When a gas is compressed more molecules are contained in a given space, hence the bombardment increases both on account of increased number of molecules striking and on account of increase in number of times of striking per second. This explanation completely satisfies and explains the behavior of a gas in its relation to pressure and volume and also explains deviation from this relation, known as Boyle's law, and does it accurately and efficiently, so that theory is completely in accord with practice. In general, the kinetic theory of gases is the only thing that completely explains the behavior of gas under all conditions and, further, it not only does this but it has foretold many phenomena previously unknown and these have been verified by experiment.

In addition, it explains many things in thermodynamics. It shows whether Carnot's cycle, as utilized in the change of heat into energy and *vice versa*, is the most efficient possible transformation that can be obtained. The Carnot cycle consists of two adiabatic and two isothermal changes alternating. Work can be obtained from heat only by expanding a gas at a higher temperature or higher pressure than that at which it is compressed. Thus in Carnot's cycle, if a gas is expanded isothermally as far as it can be by the limitations of the machine, each molecule hits with its maximum kinetic energy and as soon as it rebounds it obtains the same from the walls of the vessel. It is reduced to the lower temperature adiabatically, that is, most efficiently. No heat is obtained from the walls of the vessel during this change and it reaches the lower temperature and pressure with minimum effort. Then in compression each molecule is hit by the piston when it possesses its lowest possible kinetic energy and the access of energy given it at this time is lost to the walls of the containing vessel before it is hit by the piston again. Hence this compression is most efficient and in the following adiabatic compression the gas is returned to its higher pressure and temperature with a minimum loss, since no heat or energy during this transformation goes into the walls of the vessel.

There is no doubt that a study of the kinetic theory of gases completely elucidates many of the obscure points (and in fact all of them) in the conception of the compression of gases, if it is investigated sufficiently. Of course this is work primarily for physicists, but engineers are daily becoming more and more interested in physical science and it is absolutely necessary today that a compressed-air engineer, or manufacturer, or even the consumer, should know enough of this development to understand the phenomena which are going on inside of the compressor. By this means reheating, and the reason for the increased efficiency obtained thereby, become simple and clear. The presence of moisture in the air and its effect on the efficiency also are easily understood.

The Hydraulic Elevator—X

How to Construct Traveling-sheave Frames, Strengthen Foundations and Supports, and Avoid Piston and Cylinder Friction

BY WILLIAM BAXTER, JR.

In previous articles in this series the traveling sheave has been shown as if moving unguided in its path. This construction was universally employed some years ago and most vertical-cylinder elevators in actual use are so arranged; but nowadays very few machines are installed with unguided sheaves. The modern practice is to construct a substantial frame, provided with shoes that usually run on iron guides, to hold the traveling sheaves. A sheave frame of this kind, as made

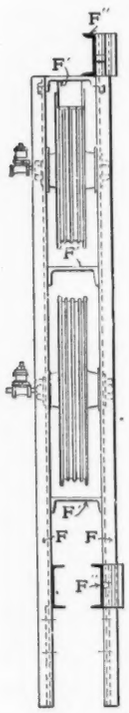


FIG. 95

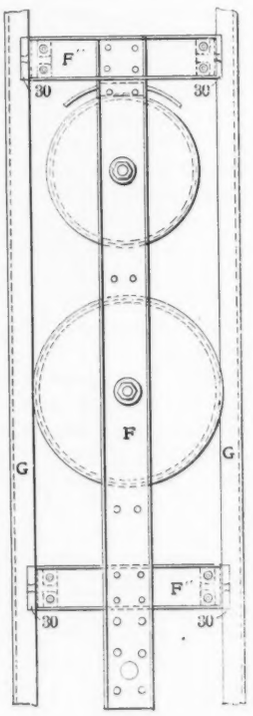


FIG. 96

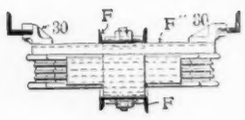


FIG. 97

by the Otis Elevator Company, is shown in Figs. 95, 96 and 97, the first two being end and side elevations and the third a plan view. This frame consists of sides *F F* made of channel beams about nine inches wide, with connecting pieces *F'* above, below and between the sheaves, guide-holding channel beams *F''* being placed at the top and bottom. On the ends of the channels *F''* are secured guide shoes *30*, which run on the guides *G G*. The lower beam *F''*, Fig. 96, and a similar one opposite, as clearly shown in Fig. 95, form a support for the counterbalance weights, and the distance between the beams and the lower sheave is sufficient to permit the use of as many weights as may be required. The lower ends of the side

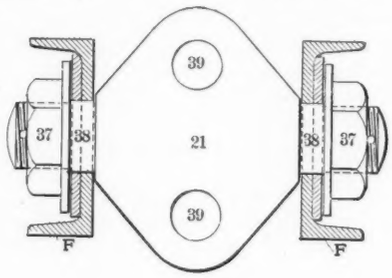


FIG. 98

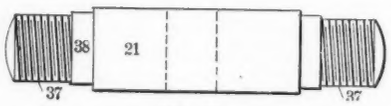


FIG. 99

frames *F F* are reinforced by flat plates riveted to them, so as to afford proper bearing for the trunnions of a crosspiece through which the upper ends of the piston-rods pass.

The construction of this piston-rod connection is shown in Figs. 98 and 99; Fig. 98 also shows a section through the lower ends of the side frames *F F*, from which the position of the reinforcing plates can be seen. The trunnion ends of the piece *21* are so made that the nuts *37* can press the washers against a shoulder before binding on the side frame, the bearing *38* being considerably larger than the screw, as clearly shown in Fig. 99. Thus the piece *21* is free to swing and thereby equalize the strain on the two piston-rods, these passing through the holes *39*. The equalizing of the strain is not perfect, however, for if the piece *21* is tilted much, the nuts on the high side will have a bearing on the outside edge, while the nuts on the low side will bear on the inner edge; therefore there will be considerable difference in the leverage. Owing to this fact, whenever it is found that the crosshead *21* is out of square with the piston-rods, it should be trued up by screwing down the nuts on the high side.

The studs on which the sheaves revolve are constructed as shown in Fig. 100. They consist of two parts, a steel center stud and a brass outside sleeve. The stud reaches from outside to outside of the frames *F F*, while the brass sleeve is a trifle longer than the width of the sheave-hub; hence, when the nuts are tightened, the sleeve is prevented from rotating, as a consequence of being tightly clamped between the side frames. A thin strip is set in one side of the stud *32* and keyways are cut on opposite sides of the diameter of the brass sleeve to slide over this strip. Through the center of the stud an oil duct extends from end to end, so that an oil-cup may be mounted (see Fig. 96) on either side of the sheave. From this central oiling channel radial ducts are run as shown in the enlarged view of the stud, Fig. 101, and in the bore of the brass sleeve are grooves to match the holes in the stud, as shown in Fig. 102; from these grooves ducts extend to the outside. It will be seen that whatever the position of the stud, there will be a clear passage from

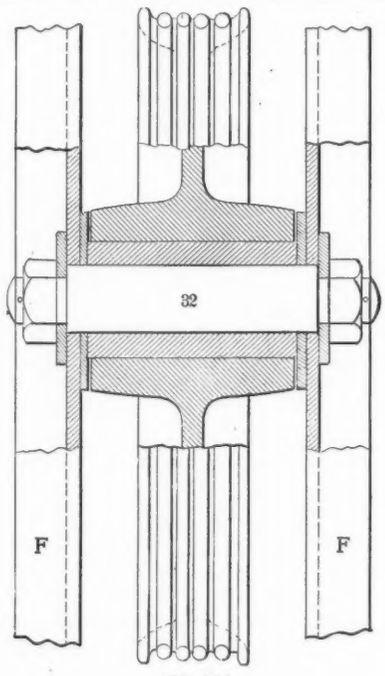


FIG. 100

the oil-cup to the outer surface of the brass sleeve which forms the sheave bearing. The sleeve has two keyways, so it may be reversed when one side is worn out, the pressure on the sheave-bearing being always in the same direction; and it makes no difference how much space there may be on the upper side; in fact, space at this point is a benefit, if anything, as it serves to collect the lubricant so it will be spread evenly over the bearing surface.

Why the Piston Is Weighted

In each of the sectional drawings of vertical cylinders already shown the piston is represented with a number of counterbalance weights resting upon it, and no doubt many readers have wondered why this construction is used, inasmuch as it increases the length of the cylinder and therefore its cost. The reason can be made perfectly clear by the aid of Fig. 103, which will be recognized as the lower end of the cylinder and the valve chamber. Suppose that the piston has just reached the point where the automatic stop-valve begins to swing around to the right side to cut off the outflow of water, and that after the piston passes over one-half the remainder of the stroke the automatic valve closes the outlet completely, then, if the piston still persists in going down, the water under it must lift the relief valve *22* in order to escape. If the car is running upward very fast at this instant, as is likely to be the case if the load is light, the momentum will be great and the car will tend to keep up its motion after

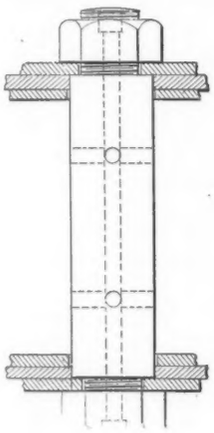


FIG. 101

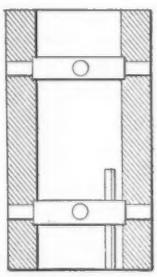


FIG. 102

the stop valve has closed the outlet. The momentum of the traveling sheave and piston will also be considerable but not as great as that of the car, owing to the lower velocity. The sheave, however, will move down as rapidly as the car goes up, but the piston might not do so, because to descend with a velocity equal to that of the traveling sheave it would not only have to overcome the friction of all its parts, but it must also have sufficient energy left to force the water through the valve *22*. The momentum of a light piston would be insufficient to do all this work; therefore it would lag behind and the piston-rods would slacken up; in extreme cases the rods might be forced up through the crosshead in the traveling-sheave frame.

Thus far I have considered only what would take place if the car were arrested by the action of the automatic stop while ascending, but it can be readily seen that if at any time during the up trip the operator closes the main valve too quickly when the speed is high, the same effect will be produced. To prevent such an occurrence the piston is weighted. It may be suggested that it would be preferable to make the piston heavier, instead of adding counterbalance weights, and this is very true; but heavier castings would have to be handled and there is room for an honest difference of opinion whether it would be advisable to save pieces by increasing the weight of a part which has to be finished in a lathe, and which in the process of erection has to be handled with great care.

To Prevent Friction

As the weight of the piston alone causes it to descend, it is evident that it is necessary to restrict the resistance to motion

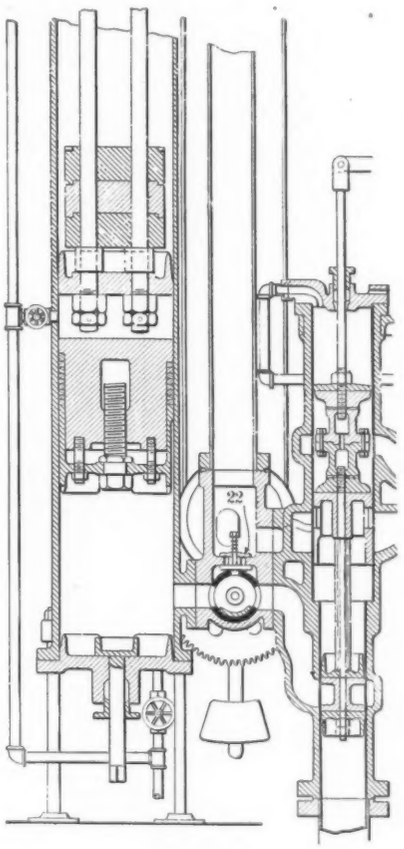


FIG. 103

to minimum at all times, otherwise the stopping and starting on the up trips may be very unsatisfactory. If the piston packing is too tight sufficient friction may be developed to retard it unduly when the car stops on down trips, even if the stops are not abnormally sudden. If the cylinder is not well lubricated, also, the friction may increase enough to interfere with the movement of the piston; therefore, this point should not be overlooked. An oil-cup is provided at the side of the cylinder and if this cup is filled every ten days or two weeks and the cocks opened for about half an hour, the oil will run in and being lighter than the water will rise to the surface and collect under the bottom of the piston, whence it will gradually spread over the cylinder surface. After the oil has drained out of the cup, the circulating cocks must be closed; if they are not, water will escape and the car will settle while stopped at the landing. Cylinder-oil is the proper lubricant for this purpose. It is seldom necessary to oil the cylinder oftener than once in ten days, because the water itself acts as a lubricant. If the cylinder requires lubrication it can be detected by a rumbling and also by unevenness of motion. These symptoms, however, are not always an indication that the cylinder requires oiling, as they may be produced by inequality of tension in the piston-rods, which will cause one side of the piston to sag and bind in the cylinder. This condition can be detected by examining the crosshead plate in the traveling-sheave frame, to see if it is square with the piston-rods, and also by noticing if the rumbling and chattering are unequal on the up and down trips. If there is more noise when the piston is going up, it indicates that the rods are not strained equally.

In addition to keeping the cylinder prop-

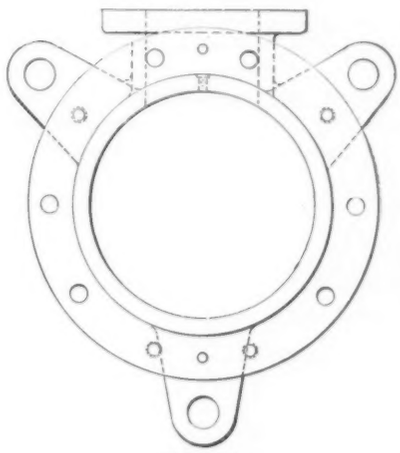


FIG. 104

erly lubricated, and the piston packing properly adjusted, it is necessary to keep the relief valve *22*, Fig. 103, in proper working order. A light spring is used to hold this valve to its seat because very little tension is required, but if it becomes clogged it may not move freely enough to allow water to pass through the valve as fast as necessary to avoid holding the piston back, causing the piston-rods to slacken up. When the car is going down, as the water in the cylinder simply circulates from the top to the bottom of the piston, the pressure above and below the valve *22* is nearly equal, hence slight pressure is needed to hold the valve to the seat. When the car is going up the lower end of the cylinder is connected with the discharge pipe, so that practically all the pressure is removed from under the valve *22*, hence no spring pressure is required to keep it closed. On an up trip, when the elevator is stopped either by moving the main valve or the automatic valve, the momentum of the descending piston will act to compress the

water in the lower end of the cylinder and thus force it up through the valve *22* into the lower end of the circulating pipe. If the valve *22* lifts easily and opens wide enough, the water will be forced through it as fast as may be necessary to prevent holding the pistcn back; but if the valve moves hard, or does nbt lift enough, the piston will be held back and the piston-rods will slide down through the holes in the upper end, until the momentum of the car and traveling sheave is absorbed, then the weight of these parts will cause them to descend and pull the piston-rods back until they reach their bearing, when the car will stop with a jolt.

The automatic-valve chamber is provided with openings opposite the valve *22* to permit of easy access to the latter. To open up this valve chamber it is necessary to draw the water from the circulating pipe and, unless the piston is perfectly tight, also from the cylinder. Of course it will be understood that the valve in the supply pipe must be closed first. It is considerable of a job to get at the valve *22*, but fortunately it is not often necessary; for unless the elevator behaves unsatisfactorily in making stops on the up trip it may be taken for granted that there is nothing the matter with this valve. Then, too, if such stops are not as perfect as they should be, the fault may not be in the valve *22* but in the cylinder, hence the latter should be put in proper

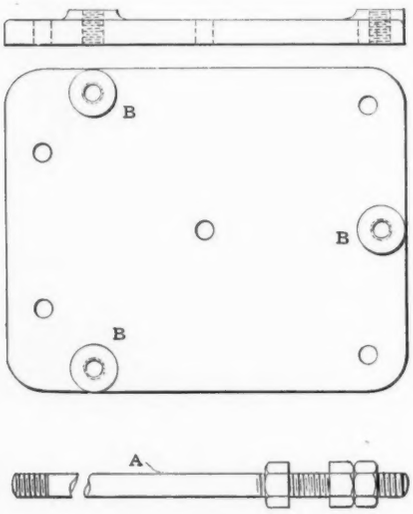


FIG. 105

condition before attempting to clean out the chamber of the valve *22*.

Common Method of Anchoring Cylinders

When water under pressure is admitted to the upper end of the cylinder to lift the elevator car, it not only acts to force the piston down, but by pressing against the under side of the upper head acts to lift the cylinder, and unless the latter is held down firmly, it will go up in the air and the car will remain stationary. Thus it will be seen that the cylinder must be well anchored to keep it from lifting, particularly if the elevator is geared high, say with a ratio of four or six to one. The most common way of anchoring vertical cylinders is by bolting them to a foundation of such size that foundation and cylinder will weigh more than the pressure of the water on the under side of the top cylinder-head. The cylinder has three strong lugs at the lower end, as shown in Fig. 104, which is a plan view of the bottom. On the foundation is bolted a cast-iron plate, Fig. 105, 1½ inches thick. The bolts extend nearly to the under side of the foundation and are secured in anchor plates of sufficient size to enable the bolts to lift the entire mass of masonry without breaking it. Three large connecting bolts *A*, Fig. 105, are tapped into holes *B B B* in the foundation plate and other ends pass through the cylinder lugs shown in Fig. 104, to support the cylinder. The general arrangement of all these parts is shown in Fig. 106. The bolts *B* are about 1¼ inches in diameter and long enough to hold the lower head of the cylinder about two feet above the floor. By means of

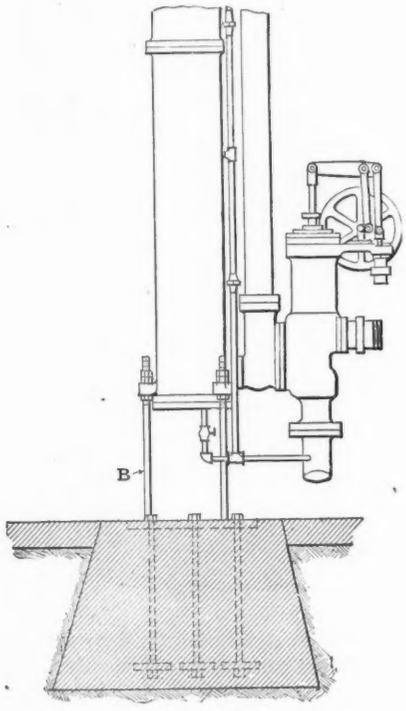


FIG. 106

nuts, the bolts can be adjusted alike. To prevent the cylinder from swaying, it may be steadied from the walls or floor, according to which may be the more convenient. Sometimes the cylinder is kept from lifting by being secured to the framing of the building, where the latter is of steel construction. In such cases the three bolts *B* simply serve to hold the cylinder in position but are not counted upon to act as part of the anchorage, because it is not good engineering to depend upon two separate supports when the construction is such that it is not possible to determine just what portion of the strain is carried by each.

For quite a while after an elevator is installed, the foundation bolts should be examined frequently to see whether they have become loose, in which case they should be tightened. The clamps which hold the cylinder against the floors of walls should also be tightened if there is lost motion at any point. The cylinder and the guides on which the traveling-

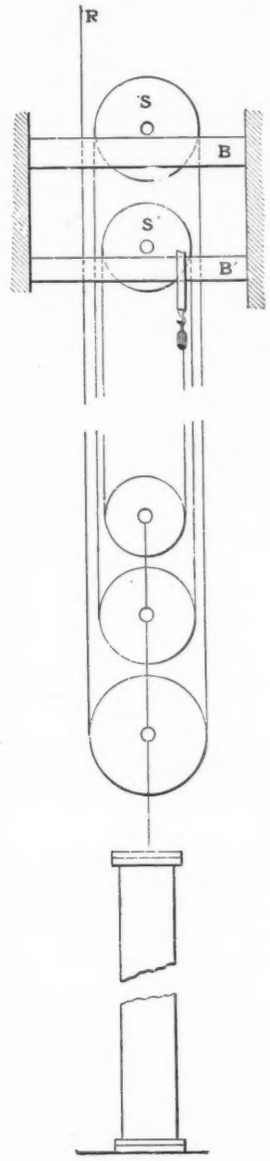


FIG. 107

sheave frame runs, should be in line with each other. As the piston-rods are of small diameter and project a considerable distance above the stuffing-boxes, when the sheave frame is in the lowest position there will not be much side strain, even if the cylinder and the guides of the sheave frame are out of line as much as half an inch; but the stuffing-boxes will eventually wear away on the side where the rods rub hard, so that it will be difficult to keep the packing tight. On this account, if it is found that the alinement is not perfect, the upper end of the cyl-

inder should be shifted. Usually this can be done easily by slacking up the clamps and putting in or taking out a liner. It may be necessary, however, to cut away part of the flange of the girder that the cylinder rests against, in order to get the parts into line. If this should be the case,

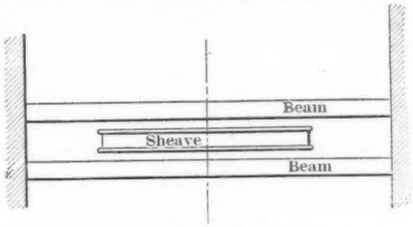


FIG. 108

it is always preferable to shift the sheave guides, unless it is certain that the girder flange can be cut away without weakening it however slightly. As a rule, if the part to be cut away is very close to the wall or other support of the girder, there will be no harm done by cutting into the flange, say, a quarter or half of an inch, but if the cutting would have to be done at a point near the center of the span it would be better not to attempt it unless assured by the designer of the building that it can be done safely. These girders are very accurately calculated by designing engineers with regard to withstanding strains, and although a large margin of safety is allowed, the removal of a portion of a flange might reduce the stiffness to an injurious extent.

How to Strengthen Sheave Supports

Not only must the lifting cylinder be properly anchored, but the stationary intermediate sheaves must be secured so that the rope strain will not pull down their supports. This will be understood from Fig. 107, in which it will be seen that only a portion of the total downward

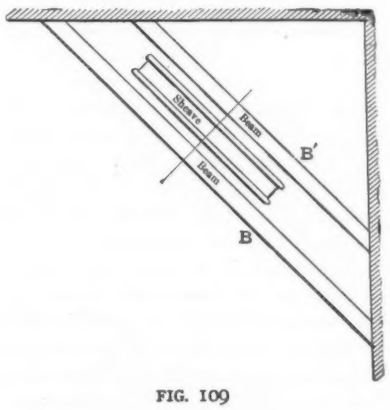


FIG. 109

pull of the piston acts on the car-lifting rope *R*, the balance being impressed directly upon the supports of the stationary sheaves *S* and *S'*. In this diagram the machine is geared six to one, so that one-sixth of the pull of the piston acts on the lifting rope *R*, and the other five-sixths on the supporting beams *B B'*, two-fifths coming on the first-named and three-fifths on the second. In all first-class buildings, the supports for these sheaves are generally strong enough, but occasionally they are not, either through faulty calculation on the part of the elevator engineers or cheap construction. The principal elevator manufacturers employ engineers who can calculate accurately every part of an elevator structure. Others, however, employ men who have no technical knowledge, but work out everything by "practical experience" and the "rule of thumb," and although such men generally err by making things stronger than necessary, in their desire to be on the safe side, they sometimes make serious mistakes and get things entirely too weak. As to the strength of the building, there is not so

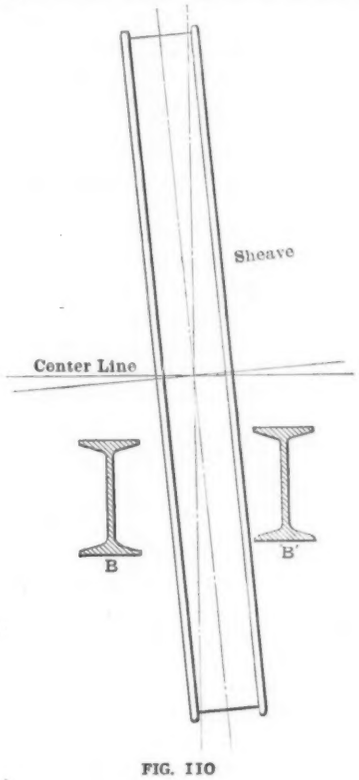


FIG. 110

much certainty. First-class office buildings are sure to be of ample strength at every point, but cheaply constructed apartment houses and family hotels, with cast-iron columns and bolted joints, cannot be counted upon as being reliable in every particular. Where the floor beams of such buildings are not stiff enough to support the beams *B B'*, the construction can be improved by means of braces extending from the beams that sustain the supports *B B'* to the floor below, or, if necessary, to the second or third floor below. In extreme cases, where it does not appear safe to trust to the building itself, a perfectly rigid construction can be obtained by running braces from the supports *B B'* to the cylinder, so that the strains will be limited to the elevator apparatus. It is understood that this construction has been adopted by elevator builders in certain western cities, for cases where buildings are cheaply built.

The building may be strong enough to afford proper support to the beams *B B'*, yet these may not be of proper size to give the required stiffness if improperly located. If they are sustained by parallel beams or walls, as indicated in Fig. 108, little harm will be done through lack of stiffness; but if they are supported by walls or beams at right angles, as in Fig. 109, there may be trouble, for as can be clearly seen the beam *B* will spring more than *B'*, owing to its greater length, and this will have the effect of throwing the sheave bearings out of line, as indicated in Fig. 110. When the support *B* sags more than *B'*, if both beams become twisted so as to remain parallel with the sides of the sheave, there will be little harm done; if, however, the beams do not twist but remain in the vertical position, as shown, the sheave-shaft will be out of alinement with the bearings, and will run hot or score, until the corners wear away enough to give a good bearing. The easiest way to surmount this difficulty, if the support *B* does not sag much, is to line up the bearings parallel with the sheave-shaft. If the sagging is considerable, the beam should be propped up, if this can be conveniently done, or it may be stiffened by riveting a plate on the side of the web, taking the strain off the sheave while the plate is being put on.

Pump Troubles and Their Remedies

By H. Jahnke

When an engineer takes charge of a new steam plant he may find that the boiler feed-pump does not work right, yet it must be kept in operation for some time until there is opportunity to take it apart to find where the trouble lies. If the engineer has not had much experience with steam pumps and their faults, he may not be able to keep the plant in operation, on account of the pump not working right. The writer has assumed charge of plants where the pumps either failed to start at all or would not draw water. Such cases usually occur in plants where the owners are unable to keep an engineer for any length of time, due to low wages, perhaps, and no engineer stays long enough to put the plant in working condition.

The first duty of an engineer in a new plant, before an attempt is made to start the pump, is to get acquainted with the discharge and boiler-feed pipes, making sure that all the valves are open that should be open. Of course this is not necessary in taking charge of a plant where the present engineer is going to leave, as in most instances the old engineer will show the new man all he wants to know about the piping arrangement.

Where an engineer has been discharged, however, the engineer who takes his place usually has to start up without this friendy aid.

At one small steam plant, the engineer of which had beeen discharged, I made an attempt, after having the fires started under the boilers, to start the boiler feed-pump, but before doing this I opened what I supposed were the valves on the discharge and feed-pipes, believing the arrangement to be as in shown in Fig. 1. When the pump was started I found it was not feeding water to the boilers. I examined it, but found nothing wrong. Then the discharge and feed-pipes were inspected and it was found that the valve *A* had been opened the night before. Upon inquiry the information was elicited that the pipe was supplying hot water for the factory and the valve was only opened a few times during the day. The pump received hot water under pressure from a heater, and when hot water was wanted in the factory the feed-valves *B* and *C* were closed and the valve *A* opened for a short time; then the valve *A* was closed

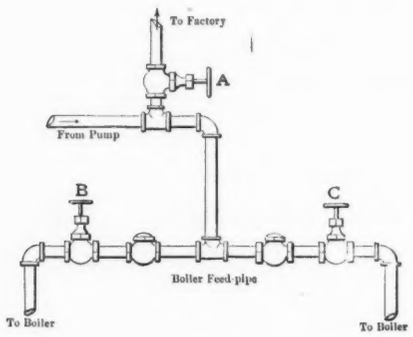


FIG. 1

and *B* and *C* opened. This appeared to be a bad arrangement, so it was changed by connecting the pipe for the factory directly to the heater, which was of the closed type and received water from the city main.

In some new plants, after the discharge and feed-pipes are put in and in use, it is found that the arrangement is not what it should be, and careless engineers, instead of making the needed changes at once, although there has been ample time to think it all out, wait until something goes wrong and then make the changes in a hurry.

Probable Causes of Pump Troubles

If upon starting a pump it is found that it pounds, this may be due to various causes, such as insufficient water supply due to an obstruction in the suction pipe, a leaky foot-valve, a loose water-piston or loose nuts. Also the water-piston may have a tighter fit at some point of the stroke, due to unequal cylinder wear, in which case reboring the cylinder will be in order. Then, again, if the pump is of the duplex type, the pound may be due to improper setting of the steam valves.

If a pump fails to draw water this may be due to the following causes: If taking water from a well or other supply, either the foot-valve of the suction pipe may leak; the suction pipe may be too small, there may be some obstruction in the suction pipe or in parts leading to the water cylinder; the lift may be too high; the water valves may leak or break; foreign matter may have lodged beneath the suction or discharge valves; the packing on the water-piston may be worn out and leaking; the seats of the suction and discharge valves may be broken, or the water valves may be prevented from lifting because the springs were screwed down too tightly.

If a pump is supposed to receive water under pressure, yet fails to get water, it may be due to some valve in the supply pipe not being opened; or the supply pipe may be clogged up; or there is a loose disk or a break in some valve, which prevents the full supply going to the pump; the valves may not be wide open; the supply pipe may be too small; the supply pipe may also furnish water for some other purpose in the factory and may be too small to supply both pump and factory. If a pump receives water under pressure from the city main, the supply pipe should be run direct from the water meter to the pump, and not used for any other purpose, unless the pipe is large enough to supply enough water for both places.

Engineers are often troubled by a groaning noise in pumps; this groaning may be due to any of the following causes: The cylinder-oil used may be too heavy (cases are known where the use of lighter oil has cured the trouble); the piston-ring edges may have become so sharp that they scrape the oil from the cylinder walls; if the water-piston packing is too tight, the excessive friction will cause a groaning.

Graphite Mixture Cures Groaning

Groaning in a cylinder can often be cured by the application of graphite mixed with cylinder-oil, forced into the cylinder with a hand-pump.

Fig. 2 shows an arrangement I intend to place on my pumps for feeding graphite and oil to the pumps once a day, or as often as may be necessary. A 2-inch nipple about five inches long is provided, with a 2x¼-inch reducer on each end; one end is screwed directly into the steam chest by means of a ¼-inch close nipple, and on the other end is a ¼-inch close nipple with a ¼-inch tee. Then a close nipple and valve are placed in the steam pipe of the pump above the valve, and a pipe is run from the valve to the feeder, as shown. The reason for placing the valve above the pump valve is to be able to use the full boiler pressure to force the graphite into the cylinder when the pump is throttled down.

The operation is as follows: When it is necessary to feed the graphite mixture, the plug *A* is removed from the tee and a supply of graphite and oil placed in the feeder, the plug is replaced and the valves *B* and *C* are opened, when the graphite will be forced into the steam chest and cylinder.

Correcting Unequal Stroke

One side of the writer's duplex steam pump used to make a shorter stroke than the other, due to the water cylinder being worn, and no amount of adjusting of the steam valves would remedy the trouble. Then was tried the following method, which readily overcame the difficulty: The

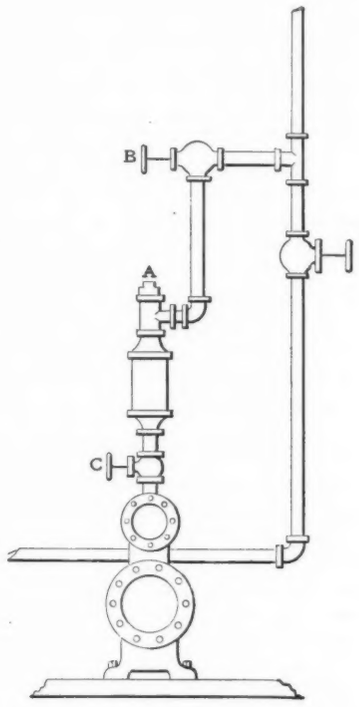


FIG. 2

piston and rod were removed from the troublesome side of the pump and the walls of the cylinder were covered with graphite mixed with a little engine-oil, well rubbed in; the piston and rod were replaced and the pump was run slowly with no water in the water end for a short time; then the pump was put in service again, when this side ran much better than the other. The other side was treated in like manner, when both pistons made a full, even stroke, and when the pump was not in service the pistons could be moved easily by hand, which showed that there was not much friction in the water cylinder. It was also found that the water-piston packing will last much longer, and that this treatment is likewise excellent for the steam cylinders of pumps and even engines, and they are so treated whenever the pistons are taken out for any reason.

If a pump begins to run more slowly

with the steam valve wide open, if the pump is in good condition, the trouble may be due to an obstruction in the feed-pipes, such as scale.

A short time ago one of the writer's pumps began to slow up every day, with the steam valve wide open. At first I thought that the steam piston was running dry, but feeding more oil did not remedy the trouble; then the check-valves on the feed-pipes were examined, when it was found that the checks were so covered with scale that they could not lift sufficiently to admit the water the pump forced into the pipes, and of course the pumps had to slow up. When the checks were cleaned the pump worked as before. I would advise engineers who use very dirty water for the boilers to examine the check-valves in the feed-pipes whenever the boilers are washed out.

Frequently engineers fail to examine the packing in the water-piston until the pump refuses to supply water to the boilers, or otherwise behaves badly, and when looking for the cause they find that most of the water-piston packing has disappeared and may be lodged beneath the water valves or in the feed-pipes. This is obviously bad practice; the cylinder-head should be removed frequently to see what condition this packing is in. If it begins to show signs of giving out, it should be removed at once and replaced by new packing, no matter if the pump has been doing good service, for if this not done the pump is liable to fail at any moment.

The water valves should be examined in like manner, and if it is found that they are beginning to leak, valves of hard composition, such as are used in pumps handling hot water, should be refaced at once by rubbing the valve on a sheet of fine sandpaper laid on a smooth, flat surface. It is also a good plan to have a good set of new valves in stock, as one can never tell when a valve is going to break or meet with some other accident. Another bad practice is to start a steam pump in the morning, after it has been standing idle for some hours, without opening the drain-cocks on the bottom of the steam cylinder. These cocks should be opened so that the water of condensation will drain out of the cylinder. They should be closed again, of course, as soon as the condensate is blown out of the cylinder.

In conclusion it may be stated that a steam pump should receive the same attention as a steam engine.

The highest mercury columns, says the *Mechanical Engineer*, are those fixed in the wall at Butteaux-Cailles (500 meters = 660 atmospheres), in a mine near St. Etienne (400 meters = 530 atmospheres), and on the Eiffel tower (300 meters = 400 atmospheres). The highest mercury column in England is to be found in Manchester. It is only 53 meters high.

To Indicate the Amount of Feed-water Pumped into Boilers

By F. Sawford

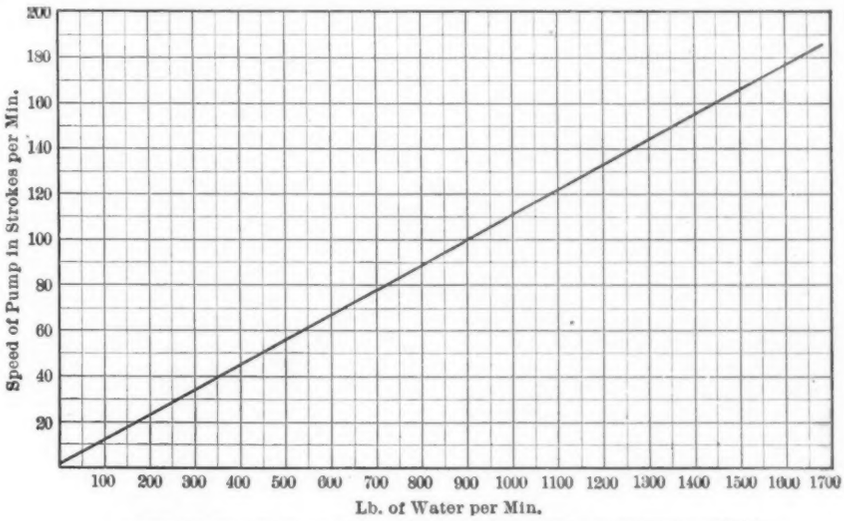
In no other part of the power plant is there more urgent need of some simple device for indicating the amount of work being done than with the apparatus for feeding water into the boilers. A counter for recording the number of pump strokes, a water meter, or other method of measuring the water, will show the amount pumped during a given period, but will not indicate the rate of flow at any instant. What is wanted is the equivalent of the ammeter on a switchboard. The gage glass cannot be said to be this equivalent, as it only shows the water level, not the rate at which the water is going in. An engineer who knows his plant can judge fairly well how much he is putting in by the speed of the pump, when that is in sight; but in many plants the practice of locating the feed-pumps in a separate room from the boiler room often renders even this unavailable.

It must be understood that these remarks apply only to the normal running conditions of the plant, as of course when tests are being taken suitable provision must be made for accurately measuring the actual amount of feed-water used during a given period.

In a plant with which the writer was connected, consisting of six Babcock & Wilcox boilers, each capable of evaporating 12,000 pounds per hour, duplex steam-driven pumps were installed to supply the necessary feed-water. These were placed in the boiler room, and difficulty was experienced in keeping them in good condition on account of coal dust, which cut the pump plungers badly and caused excessive wear generally.

It was decided to install a motor-driven pump in an engine room at the rear of the boiler house, where it would be under the care of the engineer and free from the dust and grit. The controller was located in the boiler room. Current was obtained from the three-wire system, making two voltages available, which allowed ample variation in the speed of the pump to meet the varying boiler loads. With this arrangement, it was found necessary to provide means of indicating, so the boiler attendant could see whether the pump was running properly and at what speed.

The pump was first tested to ascertain the amounts of water delivered at various speeds against a head equal to the boiler pressure, and from these data a curve was plotted as shown in the accompanying diagram. A small 10-volt, shunt-wound generator, such as is used for gas-engine ignition, was connected to the pump and driven by a belt from the motor spindle. The shunt field was excited from the 125-volt direct-current mains, with a 32-candle-power lamp in series, thus obtaining a practically constant field strength. The voltage obtained from the small generator was then exactly proportional to the speed of the pump.



CURVE SHOWING AMOUNTS OF WATER DELIVERED AT VARIOUS SPEEDS

The next step was to install a large illuminated-dial voltmeter directly above the controller, in which position it was visible from any part of the boiler room. Instead of showing volts, the voltmeter dial was marked to indicate pounds of water per minute, which were proportional to the speed of the pump, as shown by the curve. To check up the indications of the meter at any time, it was only necessary to take the pump speed and compare the meter reading with the corresponding amount of water shown on the curve. It was not necessary to take the efficiency of the pump into consideration, as the curve was plotted from the actual amount of water delivered at various speeds.

This device was found extremely useful to the boiler attendant, who, being able to read the amount he was pumping at any time, and knowing from long practice the variation of load on his boilers was able to anticipate the demand and keep the water level constant.

Modern Safety Devices for Prime Movers

The Salient Features of Various Engine-stop and Speed-limit Systems, and their Application, Described and Illustrated

BY C. C. MAJOR

The large number of fly-wheel accidents, with the resultant loss of life and property, makes this subject an important one to every steam user, and a recognition of this fact is shown in the increased number of safety devices which are being installed in new and up-to-date power plants. Most steam engines are operated without any special safety device other than the governor, yet the damage wrought by a bursting fly-wheel is sometimes greater than that resulting from a boiler explosion and it would be difficult to find a man who would install and operate a steam boiler without a safety-valve.

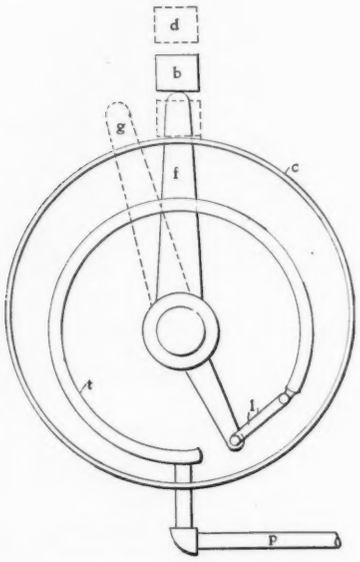


FIG. 1

The average steam user, who carries fly-wheel insurance which includes inspection at stated intervals and employs a good engineer, thinks that he has done all that is necessary to prevent accidents, or if accidents do occur, the losses are covered by the insurance. Prevention, however, is always better than cure, and while a good governor and a good engineer are desirable and necessary, they do not prevent accidents. A number of causes may interfere with the proper function of an engine governor, and the engineer, however good, cannot always stand at the throttle valve ready to shut off steam. In many plants, and especially in small ones, the engineer has other duties to perform which may necessitate his absence from the engine room for short periods of time. In such cases some automatic safety device is very essential, as it takes but a remarkably short time for the engine to speed up to the danger point if the governor belt breaks or the load goes off suddenly and the governor-stop does not act. In many cases of this kind the governor shuts the engine down before any damage is done, but an average

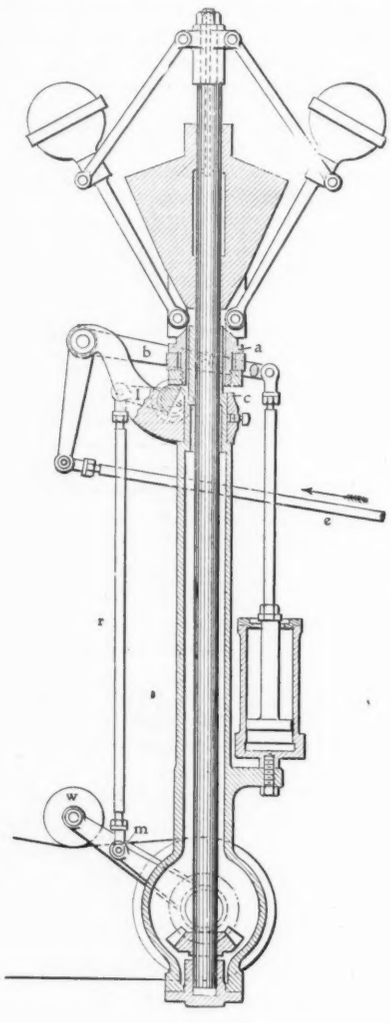


FIG. 2

of ten fly-wheel accidents per month during a period of twenty months is sufficient to show that the governor cannot always be depended upon.

The writer, while instructing a class in Corliss-engine handling and valve setting at Sibley College, Cornell University, had an experience which showed to his entire satisfaction that the engineer must be pretty close at hand if he is to accomplish anything when an engine starts to "run away." After the valves had been set and each student had started and stopped the engine, it was proposed to illustrate the action of the safety stop on the governor by throwing off the governor belt, which was done.

The Barclay Stop

The engine was equipped with the Barclay stop shown in Fig. 1. This stop consists of a small pipe *p* leading from the steam chest to a bourdon tube *t* inclosed in a case similar to that of an ordinary steam gage. The end of the tube is connected by means of the link *l* to the finger *f*. When the engine is at rest and there is no pressure in the steam chest, the finger *f* assumes an upright position

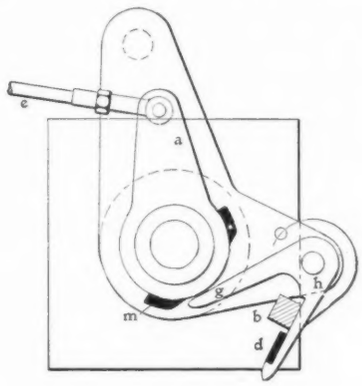


FIG. 3

(shown in the figure) and supports the governor block *b*. This position of the governor gives the longest range of cut-off, which is practically full stroke and is favorable for starting. As steam is turned on and the pressure in the steam chest increases, the pressure will overcome the resistance of the bent tube *t* and the finger *f* will take the position *g*, shown in dotted lines. By the time this movement of *f* takes place, the engine has attained sufficient speed to cause the governor to raise the block *b* to the position *d*. If the governor belt should break, the block *b* would drop down upon the case *c*, in which position of the governor the hooks on the lifting arms will not engage with the blocks on the dash-pot arms, and steam will not be admitted to the cylinder, thus shutting down the engine.

Just before throwing off the governor belt, an unusually heavy demand for steam had been made on the boilers and the pressure had dropped sufficiently to allow the finger *f* of the safety stop to

assume an upright position, so that when the belt was thrown off, the governor dropped to the position for longest cut-off. The engine had only a light brake load and immediately began to race. The writer stood close to the throttle, but before this could be closed, the engine had attained a very high speed, which fortunately did no damage in this case. Had the governor belt broken instead of having been purposely thrown off, the engine would have run away and possibly no one would have been near enough to close the throttle in time to avert an accident.

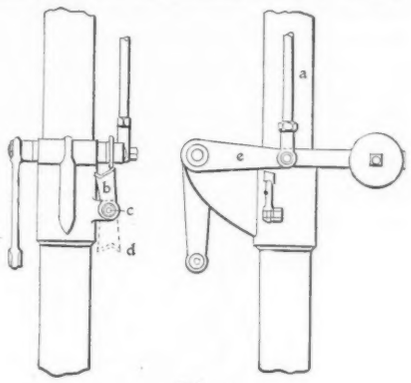


FIG. 4

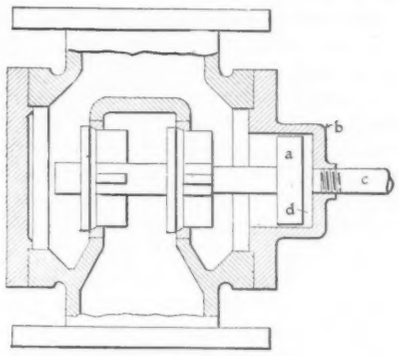


FIG. 5

Stops Divided into Two Classes

Safety stops may be divided into two classes: First, those which are placed on the engine by the builders and form a part of the completed machine. These stops are usually a part of the governing mechanism and operate through the inlet valves of the engine. There are about as many types of this class of stops as there engine builders. The second class comprises those which are separate and distinct from the engine and when installed operate the throttle valve or a separate steam valve just outside the throttle valve. These stops may be installed so as to be operated from various points about the plant, which is a decided point in their favor as circumstances may arise making it necessary to shut down the engine very quickly, as in the case of someone being caught in the machinery, and valuable time would be consumed in notifying the engineer to stop the engine; or a cylinder-head might blow out or a belt break, which would make it impossible or extremely dangerous to approach the throttle valve.

There is another class of apparatus which may be included among these safety devices which comprises what are sometimes called isolating valves or automatic stop-valves. These valves are usually installed in connection with boilers, but when such a valve is placed in the steam line to the engine, it will operate when the pressure on the engine side is reduced, as would be the case when a cylinder-head blew out, or it could be operated from distant points to which small emergency pipes were run. To stop the engine, it would simply be necessary to open a globe valve at some convenient point in one of these emergency lines. The first class of safety stops is usually found on Corliss engines a few types of which will be illustrated and described. The Barclay stop, Fig. 1, belonging to this class, has been described.

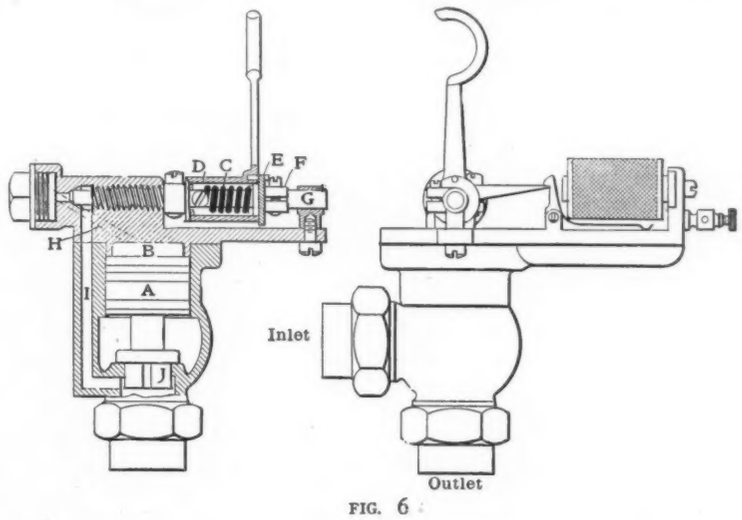


FIG. 6

Filer & Stowell Stop

Fig. 2 shows the Filer & Stowell governor and stop, in which the sleeve *a* rests upon the support *s*, which is connected to the pulley *w* through the levers *l* and *m* and the rod *r*. The pulley rides upon the governor belt and if this belt should break or become unlaced, the pulley will fall and rotate the piece *s* so as to allow the sleeve *a* to drop down upon the shoulder *c*. As *a* descends, it causes the bell-crank lever *b* to move the reach-rod *e* in the direction indicated by the arrow. Now by referring to Fig. 3, it will be seen that this will bring the safety cam *m* forward under the inner member *g* of the hook *h*. When *g* rides upon the safety cam *m*, the hook is thrown outward, the die plate *d* will not engage with the block *b* and the inlet valve will not open, thus closing down the engine. This stop and the one previously mentioned have the advantage of requiring no attention from the engineer, such as the adjustment of a collar or removal of a pin to put the stop in working condition.

If the shaft and governor belt in Fig. 2 should become wet from a bursting pipe or other cause, the belt might slip, allowing the governor to fall without moving the safety stop, which would hold the governor in the position for longest cut-off and cause the engine to "run away." This is an objection to stops which move to the safety position only upon the breakage of the governor belt.

FIG. 7

Harris Engine Company Stop

The Harris Engine Company supplies its engines with a very simple form of stop, shown in Fig. 4, where *a* is a portion of the governor column to which is attached the safety stop *b*. This consists of a single piece tapered at the top as shown and free to turn on the pin *c*. When the engine is running, the stop hangs down in the position shown by dotted lines so that if the governor falls from any cause, it will drop to such position that the safety cams will prevent the inlet valves from opening. Just before stopping the engine, the engineer is expected to throw the safety stop up. As the center of gravity falls inside the pin or bolt *c*, the stop will remain in position

to receive the lever *e*. As *e* gradually descends, it engages with the tapered portion of the stop, causing it to move outward, so that when *e* comes to rest at the bottom of the V-shaped portion, the center of gravity of the stop is outside the point of support *c*. When the engine is started, the governor rises, and the stop drops into the safety position *d*.

Two representative safety stops belonging in the second division are the Locke and the Monarch automatic engine-stop and speed-limit systems.

The Locke System

The Locke system consists essentially of a main stop-valve placed in the steam line to the engine, an electric auxiliary valve which operates the main valve, a speed

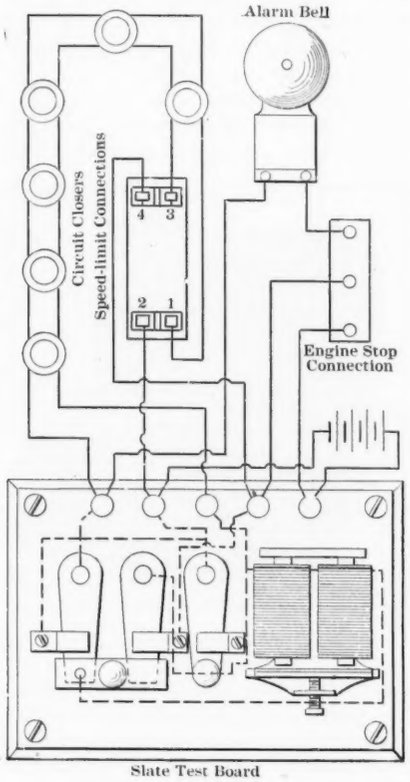


FIG. 8

limit, a vacuum breaker, and a battery and wiring system to various parts of the power house or factory. A vertical section of the main valve is shown in Fig. 5. At the end of the valve-stem is the piston *a* in the cylinder *b*. The end of the cylinder *b* is connected to the auxiliary valve through the pipe *c*. The valves and piston are so proportioned that when steam pressure acts on both sides of the piston *a*, the valve will remain open, but when steam is exhausted from the chamber *d*, the unbalanced pressure will close the valve. When steam is again admitted to *d*, the valve will open.

Fig. 6 shows a side and sectional view of the auxiliary valve, whose office is to exhaust the steam from the chamber *d* (Fig. 5) of the main valve. The pipe *c* (Fig. 5) from the main valve is connected to the inlet of this valve, the steam filling the chamber *B* above the piston *A;* the outlet, which may be piped to any convenient drain, is closed by the poppet *J*. The piston *A* fits loosely in the body of the valve and is connected to *J*. The exhaust passages *H* and *I* are controlled by the auxiliary valve spindle *G; F* is a collar clamped to the valve spindle, *C* is a spring in the cylinder *D,* which is coiled when the cylinder is latched to the armature of the magnet.

The valve operates as follows: Whenever the valve is tripped by the magnet, the spring uncoils, rotating the cylinder *D,* which carries the pin *E*. Then *E* strikes the collar *F*, causing it to rotate with the valve spindle *G* one-fourth of a turn, thus moving the valve from its seat 1/16 of an inch and exhausting steam from the space *B* through *H* and *I* to the under side of the piston *A*. As *A* is larger than *J*, the latter will be forced up, allowing steam to pass through the valve, which action closes the main valve and stops the engine.

The speed-limit device, Fig. 7, consists of a governor of the Pickering type and is belted to the engine shaft. It is designed to run in either direction and is set to operate at any given number of revolutions. It is connected in the wiring sys-

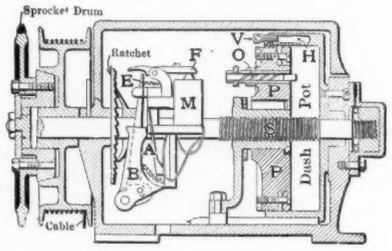


FIG. 9

tem, Fig. 8, between posts *1* and *2*, or *3* and *4*, and whenever the speed of the engine exceeds the desired limit, the circuit is closed and the automatic valve tripped, which closes the main valve.

Fig. 8 shows the test board and wiring diagram of the Locke system. The circuit closers may be located at a number of convenient points and are preferably placed in boxes with glass covers similar to fire-alarm boxes. An alarm bell is wired in the circuit so that whenever the stop is brought into action to shut down the engine, the arm of the auxiliary valve will close the bell circuit, causing a continuous ringing of the bell and notifying the engineer that steam has been automatically shut off.

In this description reference has been made only to the control of steam engines, but what has been said about controlling the steam engine applies equally well to the steam turbine, gas and oil engines, and also to motors and rotary converters.

The Monarch System

In the Monarch system, it is customary to have the main throttle valve form part of the automatic-closing device. A sprocket wheel is placed on the valve-stem instead of the usual hand-wheel, and by means of a sprocket chain engages a similar sprocket wheel bolted to the drum of the engine-stop shown in Fig. 9. This drum is fixed to the shaft and carries a cable to which is attached a weight which serves as power to operate the stop.

The tripping device and dash-pot of the stop are placed in an iron case, which prevents injury or disarrangement of any of the parts. The ratchet is fastened to the shaft and is held by the pawl *B* from turning in the direction that closes the valve. The pawl is held in contact with the ratchet by a lever which in its turn is held in place against the tension of the springs by the left end *E* of the armature. When

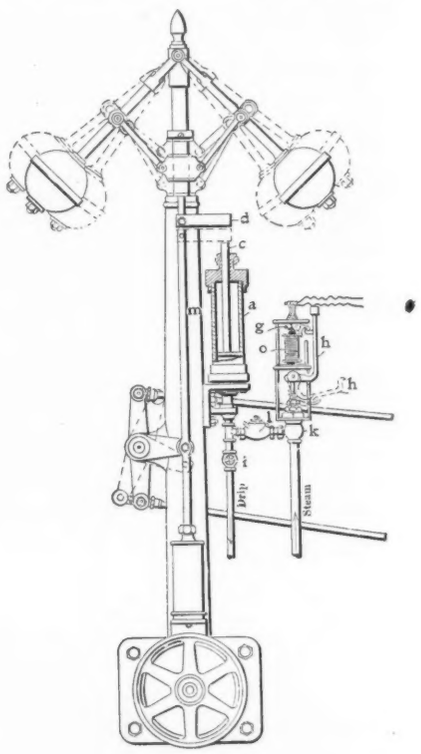


FIG. 10

the circuit is closed through the magnet *M* by the speed-limit device or push buttons, the armature *F* is pulled down releasing the lever which is drawn swiftly to the right striking a lug on the pawl *B*, throwing it out of engagement with the ratchet, allowing the weight to rotate the drum and sprocket and close the throttle.

To prevent the valve from jamming against its seat, a dash-pot is placed on the shaft. This consists of a cylinder into which the piston *P* fits closely. A square thread is cut on the shaft as it passes through a nut fastened in the center of the piston, so that, as the shaft rotates, the piston is carried into the cylinder, compressing the air and forming a perfect cushion. The speed of the stop is adjusted by means of the by-pass valve *V* that governs the amount of air that is forced through the opening *H* as the piston moves in. An adjustable releasing

valve *O* is opened by contact with the end of the cylinder. When the throttle valve is near its seat, the compressed air escapes through this releasing valve, allowing the valve to seat softly, but with sufficient force to close it tightly.

The Monarch speed-limit device differs from that shown in Fig. 7 only in detail. It is inclosed in a cylindrical iron case and can be applied to any kind of engine of any size or speed. Electrical contact is made by the centrifugal action of the balls when the speed reaches a predetermined point so that it is impossible for the engine to race without putting the stop into action and thus stopping the engine. Outside the case on the end of the governor shaft is a pulley of the proper diameter to revolve the governor at a uniform speed when the engine is running at normal speed. The pulley is belted to the main shaft and the speed limit adjusted

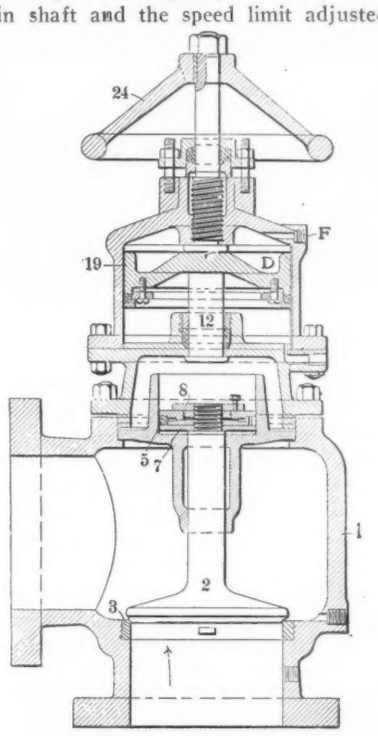


FIG. 12

to any given number of revolutions above the normal to allow for changes in speed due to variations in the load.

The Monarch Corliss engine-stop, Fig. 10, may be attached to any Corliss engine having a fly-ball governor. This stop is operated by steam pressure which may be admitted by the action of the speed limit just described or by push-buttons placed at convenient points, the same as for the Monarch stop previously described. A bracket attached to the governor column supports the steam cylinder *a*, Fig. 10, in which moves a piston attached to the piston-rod *c*. This rod engages a horizontal arm *d* clamped to the side rod *m* of the governor. Under normal conditions, the armature *g* of the magnet *o* holds the valve *k* closed. When the circuit is completed, the movement of the armature releases the lever *h* which allows the valve *k* to open and admit steam into the cylinder *a* forcing the piston upward. The piston-rod *c* engages the clamp *d* and raises the governor balls to their highest position, being held there by the check-valve *l* which prevents the steam from escaping from the cylinder. While the governor is in this position, the hooks will not engage with the block on the valve-stem levers, and the inlet valves of the engine will remain closed. To start the engine, the lever *h* is replaced, the drip-valve *i* opened, allowing the governor to fall to its normal position, and after hooking up the proper valve, steam is turned on.

A condensing engine will shut down more quickly when the vacuum is broken, and to accomplish this result an automatic vacuum breaker is wired in circuit with the engine-stop and operates simultaneously with it. The Monarch vacuum breaker operates as follows: When the circuit is closed, an armature lever is released, allowing a spring to move a valve contained in a cylinder connected to the condenser. The movement of the valve opens a port in the side of the cylinder admitting air to the condenser.

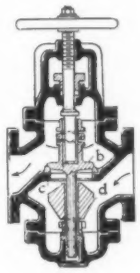


FIG. 11

The wiring system differs only in detail from that shown in Fig. 8.

H & M Combined Stop and Isolating Valve

Fig. 11 is a section of a combined stop and isolating valve of the H & M Valve Company suitable for horizontal steam mains, although other types are manufactured by the firm mentioned and by other firms. The combination consists of two separate valves, the upper or stop-valve *b* and the lower or isolating valve *d*, both of which are loose on the spindle. When the valve *b* is screwed down, it acts as an ordinary throttle valve, or boiler stop-valve; and when the spindle is raised, the valve is opened by the flow of steam through the pipe, the pressure being practically the same on both sides of the valve. If the valve is used as a boiler stop-valve, it also acts on a non-return valve; as *b* is loose on the spindle, it immediately closes if the direction of flow is reversed, as in the case of a tube bursting or other accident which would cause a rapid fall of pressure in the boiler, thus preventing the escape of steam from the other boilers into the damaged boiler.

The isolating valve *d* automatically closes in case of steam-pipe fracture or blowing out of the cylinder-head of the engine, and this valve is kept in position under normal conditions by its own weight and by the unbalanced steam pressure acting on its surface. The arrows indicate the direction of flow of steam and in case of a steam-pipe fracture or other accident, the velocity of the steam is greatly increased and overcomes the force which keeps the valve in position, causing it to close automatically against the seat *c*. It will remain closed until the valve *b* is screwed down, when the pressure will be equalized above and below the valve *d* and it will drop back to its original position. These valves are provided with test

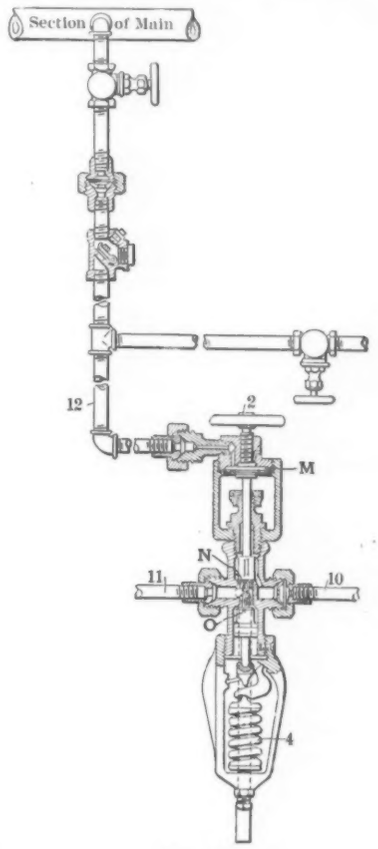


FIG. 13

levers operated by hand-wheels so that the valves *b* and *d* may be kept free and in working order at all times. They may also be operated by opening a valve in an emergency pipe which may be carried to any convenient point from the steam main between the valve and engine.

The Foster Stop-valve

The Foster combination, automatic non-return stop-valve and pilot-valve are illustrated in Figs. 12 and 13. The main valve, Fig. 12, is located at the boiler and displaces the usual stop-valve. It consists of a chamber or body *1* in which are the valve *2* and the seat *3*; the valve-stem of *2* is not continuous, the upper end passing through the piston *7* in the cylinder *5* and forming a dash-pot to allow the valve *2* to seat easily. Above the main body is the cylinder *D* containing the closing

piston *19*. This chamber is connected through the opening *F* to the outlet pipe *11* of the pilot valve, Fig. 13. The essential feature of the pilot valve is the check-valve *N* which closes the line *10-11* leading from the steam dome or drum of the boiler to the chamber *D* (Fig. 12) of the main valve. The check-valve *N* is held to its seat by the pressure of the steam acting upon the upper side of the diaphragm *M*, while opposed to this pressure is the tension of the spring *4*. The spring being adjustable, the unbalanced pressure acting to keep the valve *N* closed may be made any desired amount.

When starting from a cold boiler the operation of the valve is as follows: Close the main valve, Fig. 12, by the hand-wheel *24*, close the pilot valve *N*, Fig. 13, and open *O* by screwing down the hand-wheel *2* of the pilot valve. Open the main valve slowly, admitting steam to the steam main and through the pipe *12* to the diaphragm chamber *M* of the pilot valve. When the pressure in the chamber *M* has reached boiler pressure, turn the hand-wheel *2* back until it stops and the steam pressure on the diaphragm *M* will keep the valve *N* closed.

Should the pressure in the steam main suddenly fall from any cause, such as the blowing out of the cylinder-head of an engine, the pressure in *M* will be lowered and when it exceeds the limit at which the spring *4* has been set, the valve *N* is forced open and *O* closed, allowing steam to flow through the pilot valve and the pipe *11* into the chamber *D* (Fig. 12) of the main valve. The pressure acting upon the closing piston *19*, Fig. 12, which is of greater area than the valve *2*, Fig. 12, will cause the latter to seat and shut off steam from the boiler. The main valve may be closed by opening any of the emergency valves, which may be located at convenient points.

Wrecking a Plant after a Fire

By Wilfred Twinch

An engineer, especially in the great Northwest, is liable to run up against all sorts of odd experiences, many of them of interest only to himself, perhaps; but it strikes me that the following account of wrecking the Minnesota Sugar Company's plant, at St. Louis Park, Minn., after it was burned down, will not only prove interesting to others, but instructive as well. The plant cost $400,000. The main building and warehouses were of enamel brick, one end of the plant being of mill construction, two stories high, and the other end part steel and three stories high. Some of the heaviest machinery was supported by iron columns. The floors were wood. Figs. 1 and 2 are general views taken after the fire. After the insurance was adjusted the plant was turned over to the engineer to wreck. He was instructed to save everything worth saving, to sell the scrap and to clear the ground. In this mess there were four cast-iron evaporators, built-up structures, 20 feet long, 8 feet wide and 8 feet high, with their backs

FIG. 1. MINNESOTA SUGAR COMPANY'S PLANT AFTER THE FIRE

broken. There were eight wrought-iron crystallizers weighing 20 tons each, and there were steel storage tanks and pipe lines galore. Altogether there was sufficient salvage to preclude the use of dynamite.

The engineer had had no previous experience in wrecking, so he concluded that scrapmen could do it more cheaply. These gentlemen were found to be banded together and very difficult to deal with. At first the best proposition they would offer was to pay us $2.40 a ton for the wreck, they to clear the ground, leaving us everything we wished to retain. Finally competition got pretty sharp, and we closed a contract with one fellow to clear the ground and pay $6.75 a ton for all wrought- and cast-iron scrap, 12½ cents per pound for copper scrap, 4 cents for brass, and $3 per thousand for whole brick. Fortunately we had a lawyer to draw up a contract which contained a penalty clause for not finishing the job within 60 days.

These wreckers were certainly specialists; only such are competent to handle such a proposition. The engineer had good men in his crew, but neither he nor his men knew how to wreck a plant and make money. He has been "patting himself on the back" ever since, because he recognized his limitations, while he made money for his employer. Incidentally we learned that it is best to consider all machinery that has been in the heat of a fire as scrap, only scrap, and that cast-iron columns go through fire better than built-up columns, because they are capable of withstanding more heat.

How the Wreckers Worked

First they extended the railroad track into the wreck and procured two gondola cars, then removing by hand and team such as they could, they put the cast-iron scrap into one car and the wrought-iron into the other. Next they installed a guy derrick with a 60-foot mast, with 18x18-inch base and a 70-foot boom; also a double-cylinder, 7x10-inch hoisting engine. Care was taken in locating the derrick so it would need shifting only three times, as each move cost $50 to $60 in labor.

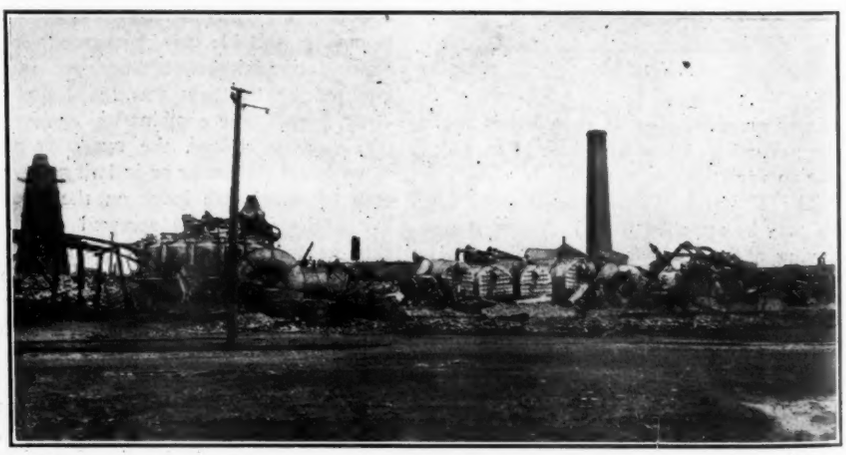


FIG. 2. ANOTHER VIEW OF THE BURNED PLANT

The big cast-iron evaporators, condensers, vacuum pans, etc., were broken up by dropping a big ball upon them from the top of the derrick. All wrought-iron

work and the steel structures were cut up with cold chisels and sledge hammers, piece by piece. To show that the workmen were not amateurs, the pipe work was unscrewed where necessary, or the flanges were broken with sledge hammers.

Fig. 3 shows the derrick in the central position. An idea of the size of the job

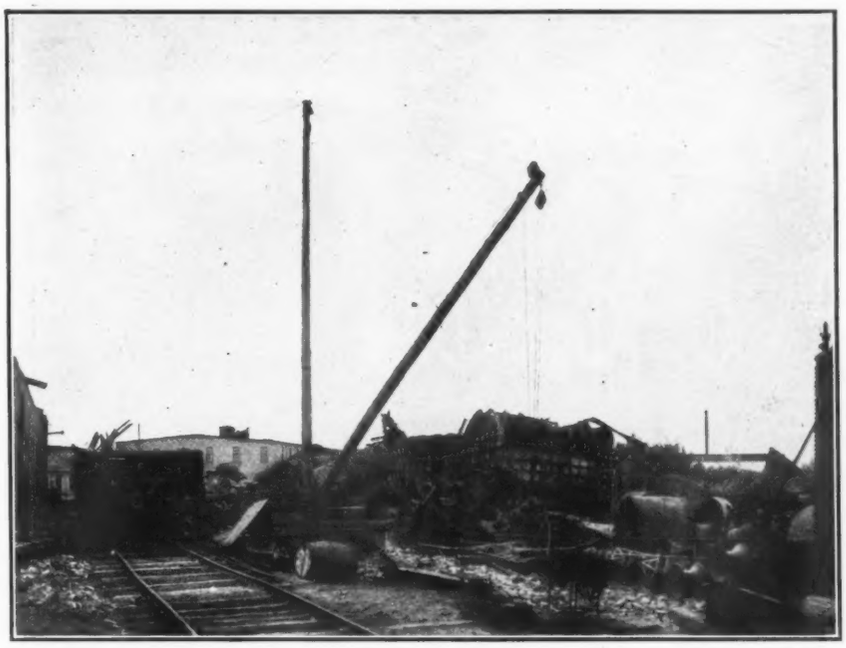


FIG. 3. SHOWING DERRICK IN CENTRAL POSITION

can be had by finding the man who stands in the center of the picture near the derrick. To the left in Fig. 3 is the boiler house, containing ten 72-inch tubular boilers. These were loaded bodily, one at a time, five being handled by the derrick in the position shown.

Cost of Wrecking the Plant

The market price for wrought- and cast-iron scrap, mixed, was $10 per ton, f.o.b. cars; the contract price was $6.75 per ton on the ground, so the contractor evidently allowed $3.25 a ton for wrecking and loading. Following is the actual cost as checked up daily by the company's engineer:

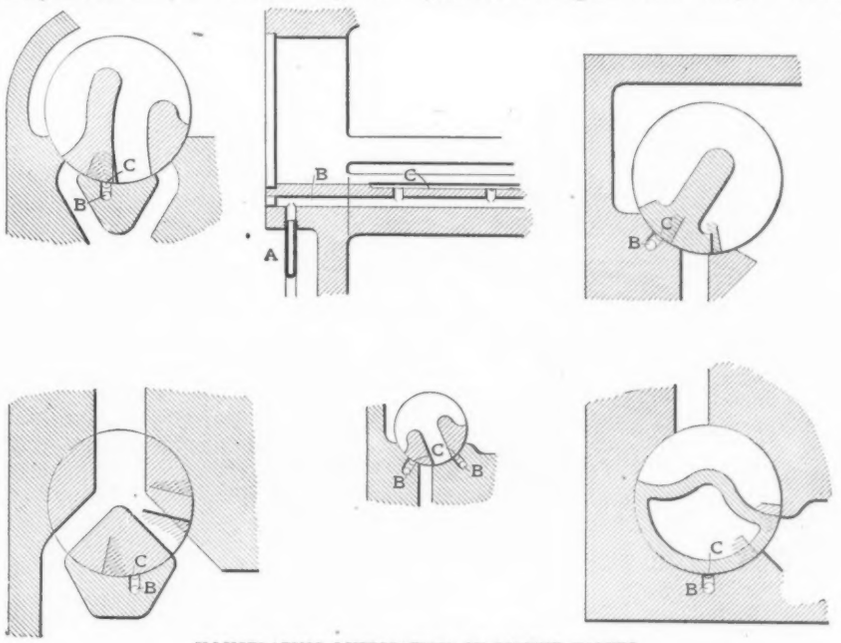
Labor (excluding derrick gang) 4500 hours at 22½ cents	$1012
Supervision, 2 men for two months, at $75	300
Team, 10 days at $4	40
Setting derrick	60
Derrick, 60 days at $12 a day (4 men)	720
Derrick repair	50
Loading derrick	50
Tools (say)	30
	$2262

There was 990 tons of scrap iron shipped, so the actual cost of wrecking and loading was $2.28 per ton. Had the engineer done the job with his crew and such labor as he could pick up, the cost would probably have been twice as much.

Lubrication of Engine Valves

By N. C. Hurst

A close study of the present method of lubricating the internal working parts of the steam-engine cylinder reveals a practice, which for economy of oil is far from good. The oil is put into the steam passages and alowed to vaporize and, more or less, to volatilize, and travel along with the current of steam. The steam coming in contact with the walls and internal parts deposits at least part of its oil burden, and the steam which does not come in contact with anything carries its oil out of the cylinder and thus wastes it.



ILLUSTRATING LUBRICATION OF ENGINE VALVES

A little thought shows that but a small percentage of the total steam flowing through must come in close contact with the faces of the valves and working parts, which means that a large part of the oil fed into the cylinder never fulfils its mission. When superheated steam is used the lubrication obtained from condensation can no longer be depended upon, and thus more oil will be required than when saturated steam is used.

To obtain maximum economy in the use of any material the material must be put, in the proper quantity, where it is most required, or where it will do the most good or save the most money. Applying this to valve lubrication means that the oil or lubricant must be put on the seat of the valve or between the valve and its seat, this being the place where the oil is required; not all over the valve and its connections, where it does no good.

Oil Pressure Required

Now it is evident that the pressure on the oil, or the oil pressure per square inch between two bearing surfaces, is equal to the pressure per square inch on the bearing, due to the weight or load the bearing carries. This being the case, the pressure required to force the oil under or between the bearing surfaces would be slightly in excess of the load per square inch on the bearing; the excess pressure being that required to overcome hydraulic friction, check-valves, etc.

In the case of the engine with a balanced valve, the oil pressure required would be slightly in excess of the steam pressure the engine works with, or within the range of the ordinary mechanically operated oil-pump now used to force oil into the steam space. Judging from the construction of some of these pumps, they are able to operate satisfactorily against a pressure a few times greater than the

average steam pressure now used, thus being able to force oil under partly balanced valves and Corliss valves. This method of lubrication would insure the valves riding on a film of oil that was neither atomized nor volatilized, no matter if high pressure or superheated steam were used.

From the valves the oil would pass directly into the steam ports and then into the cylinder, thus giving the oil little time to be acted upon by the high temperatures and so insure better lubrication for the piston and rings.

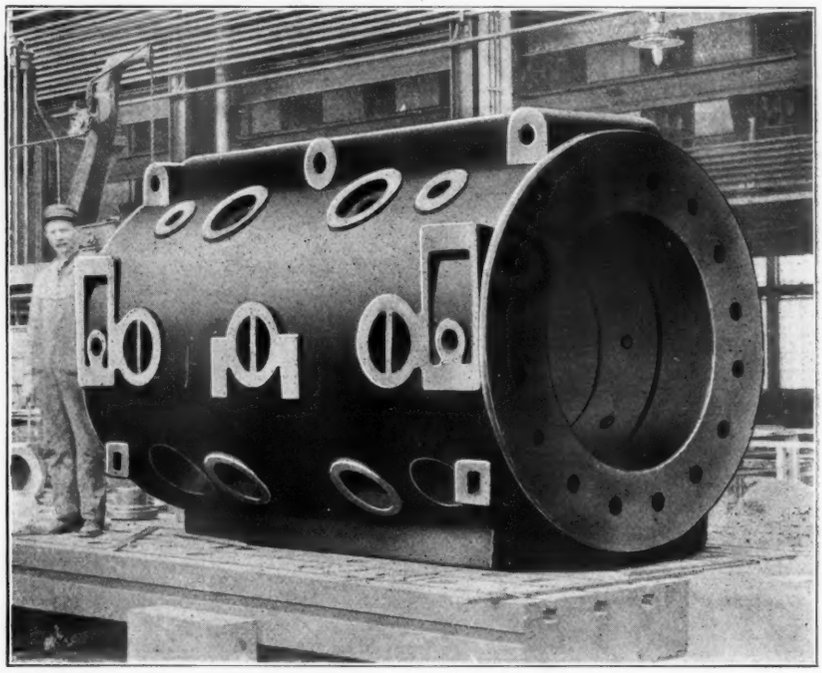
The New Method Described

The accompanying figures illustrate this method as applied to Corliss valves as generally made. The oil is fed through the pipe *A* into the passage *B* and then into the groove *C*, running nearly the full length of the valve seat. To insure the best results the oil groove *C* should at no time during the working of the valve be uncovered and thus expose the oil to the action of the steam. This may require slight alterations in some Corliss valves as now designed, and in most valves of the gridiron and slide types, but any necessary changes required to adopt this system of oiling would probably be more than paid for in the reduction of friction and saving of oil.

In some cases the cutting of the groove *C* in the valve seat may be rather difficult, especially in small Corliss valves, but the oil could be forced under the end of the valve and carried along the valve seat by means of a groove cut in the face of the valve. This scheme would undoubtedly work as well as the one with the groove in the seat, provided the width of the seat and motion of the valve were so proportioned as to keep the groove in the valve covered.

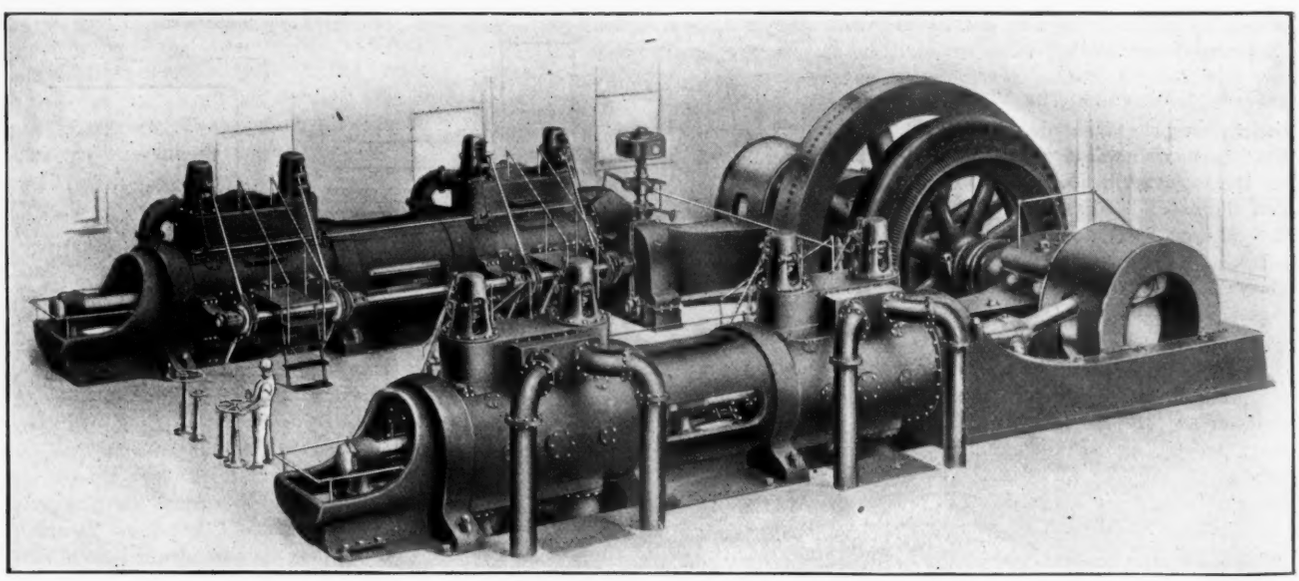
Allis-Chalmers Gas Engines

The accompanying illustrations show the type of gas engine now being built by Allis-Chalmers Company, Milwaukee, for the power house of the Indiana Steel Company's new works at Gary, Ind., and for other large installations.



ALLIS-CHALMERS 42X54-INCH GAS-ENGINE CYLINDER

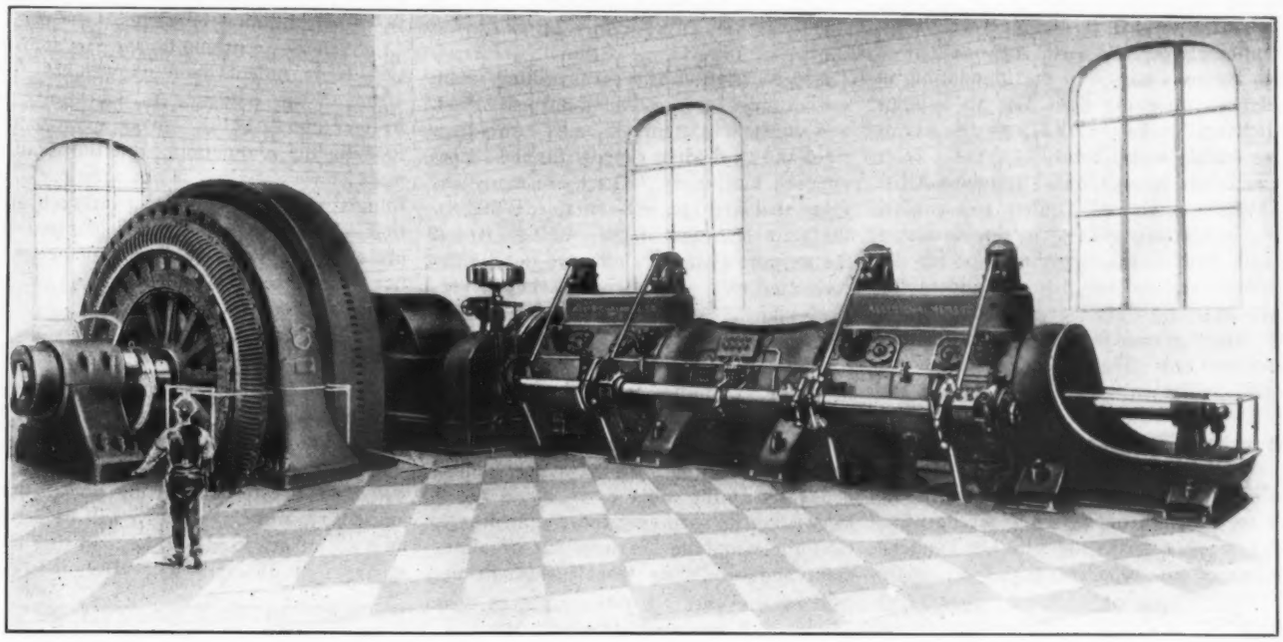
These engines have the largest cylinder diameter of any gas engine yet built in this country, the sizes being 44 inches in diameter by 54 inches stroke. They have the same volumetric capacity as the engines built for the California Gas and Electric Company, which are 42 inches in diameter by 60 inches stroke. An engine of this size on blast-furnace gas of about 80 to 85 B.t.u. will give a safe maximum horse-power in the neighborhood of 4000, but will work up to approximately 5000 horse-power on the richer gases. The valve-gear is located between the engines, as shown, is of the cut-off type, the quantity of gas and the time of admission both being under the control of the governor. The Allis Chalmers Company is building thirty-six engines of the size mentioned. In one power house at Gary there will be concentrating the gear on a twin tandem in a way that makes it very convenient for the operating engineer. This engine,



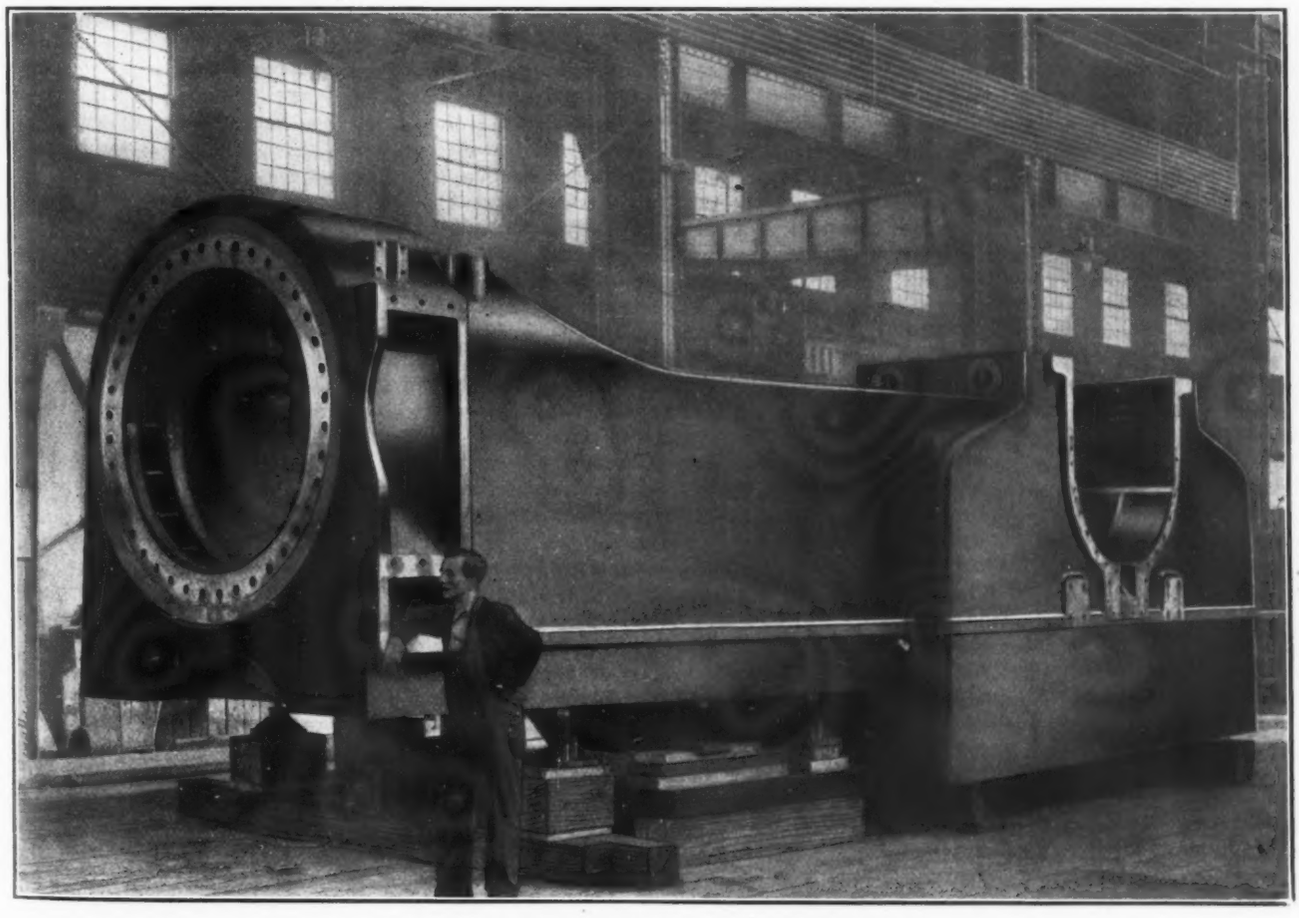
ALLIS-CHALMERS 4-CYCLE, DOUBLE-ACTING, TWIN-TANDEM GAS ENGINE AND 200-KW. A. C. GENERATOR

seventeen units of that size, fifteen of which will be connected to 25-cycle alternators (rated at 2000 kilowatts, but having, of course, large overload capacity) and two will be direct-connected to direct-current generators, also of 2000 kilowatts rated capacity. The power house is approximately 125 feet wide and 1000 feet long.

The weight of the engine is, in round numbers, 1,500,000 pounds; the crank-pins are 20 inches in diameter; the shaft is 30 inches in diameter in the bearing; and the fly-wheel is 23 feet in diameter, weighing 200,000 pounds. The speed of this engine is 83⅓ revolutions per minute. The pistons and rods are water-cooled, of course, water being introduced at the center and flowing forward to a discharge in the frame for the front piston and backward to a discharge in the tail guide for the rear piston, each piston having its separate supply. For convenience in dismantling or cleaning, the rod is made in two parts joined at the central slide, the



ALLIS-CHALMERS GAS ENGINE DIRECT-COUPLED TO ALLIS-CHALMERS GENERATOR



ALLIS-CHALMERS 42X54-INCH GAS-ENGINE FRAME

rear half going out at the rear of the engine and the other half going out through the frame, which is made open at the top to facilitate this.

The frames for this engine weigh approximately 90 tons each, and one-half of each frame is buried in the foundation, in order to raise the floor line to a point which will make the slides on the valve-gear readily accessible.

One of the views shows a standard Allis-Chalmers horizontal, tandem gas engine. This is a four-stroke-cycle double-acting engine, built in the throttling type for the smaller sizes and for rich gas, and in the constant compression or cut off type, in the larger sizes, for blast-furnace and producer gas. The cylinders are supported at the two ends only, leaving the space beneath them free to give access to the exhaust valve-gear. This, like all other Allis-Chalmers gas engines, is made with a side crank, which necessarily gives a size of shaft of sufficient strength to carry a very heavy fly-wheel. Tandem engines of this type are, therefore, available for direct-connection to 60-cycle alternators, and will work successfully in parallel.

Within the past year the Allis-Chalmers Company has taken orders for thirty-six gas engines of 4000 horse-power each, or an aggregate of 144,000 horse-power, twenty-five of which are to be installed as a part of the mammoth new plant now in course of construction by the Steel Corporation at Gary, Ind.; seven for the Homestead plant of the Carnegie Steel Company, and four in the South Chicago works of the Illinois Steel Company.

The wide use of gas engines by the United States Steel Corporation marks an important step in the progress of steel manufacture in this country, as they are designed to operate upon the hitherto waste gas rejected by the blast furnaces.

The majority of the Allis-Chalmers gas engines on order will drive three-phase electric generators of standard Allis-Chalmers 25-cycle type. These machines are to be used for generating the power to operate heavy rolls driven by induction motors, tilting- and feed-tables for the various passes, the hot saws, hot and cold pull-ups, transfer tables, straightening machines, cold saws, and other auxiliary machinery of the mills, which are now ordinarily operated by means of steam power.

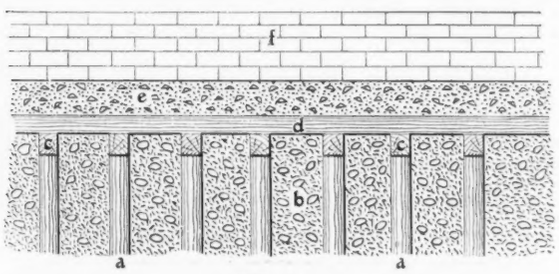


FIG. 1

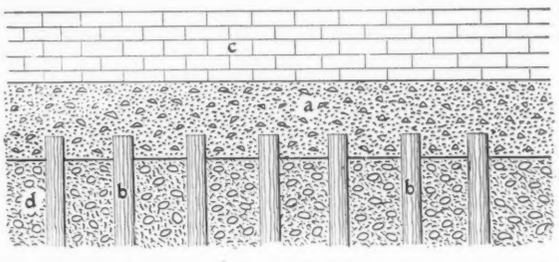


FIG. 2

Steam-engine Foundations

By R. T. Strohm

The foundation of a reciprocating steam engine must serve a double purpose. First, and most important, it must provide a rigid and unyielding support for the superimposed machinery. There are many engines that are not self-contained; that is, the main bearings of the crank-shaft and the support of the cylinder are not rigidly connected to resist relative motion in vertical planes, as, for example, an engine having a separately supported outboard bearing. Even in the case of engines with large, heavy frames connecting the cylinder and the bearings, it is imperative that the foundations shall be rigid; for any settling of one part of the support independently of the other parts would result in twisting or springing the engine frame, thus throwing the bearings out of alinement and producing trouble through the heating of the bearings. Uniform settling of a foundation is not injurious, so far as disturbance of the relative positions of the engine parts are concerned; but the connecting steam and exhaust mains may be bent or broken; and if several engines are driving the same main shaft, the latter will be sprung. Consequently, a good foundation should support its load without any settling beyond that which occurs when the machinery is first put in place.

Secondly, the foundation of an engine must absorb shocks and vibrations due to the reciprocating motion of the piston, piston-rod, crosshead and connecting-rod. It is true that these parts may be so counterbalanced by the use of rotating weights properly disposed and attached to the shaft. But in most engines the tendency to vibrate is not wholly eliminated, or counteracted, while looseness of bearings due to wear, and lack of perfect balance in a vertical plane will add to the tendency to vibrate. Such vibration, if permitted to occur, would eventually destroy either the engine or the foundation, or perhaps both. And the damage resulting might not be confined to the engine and its foundation. It must be borne in mind that the earth itself is an excellent conductor of vibrations. Consequently, in a densely built-up district, the continued vibrations set up by an improperly located engine may easily be transmitted to adjacent structures. Aside from the annoyance caused by the repeated jars and shocks, there is always danger of weakening and shaking to pieces the walls or other masonry structures of adjoining buildings.

The shock-absorbing power of a foundation is dependent upon its weight. The stronger the tendency to vibration, the heavier must be th mass of masonry forming the foundation. But the requirement of weight alone is not sufficient. The foundation must be spread over such area that when the whole load is in place the pressure per square foot of surface will not exceed certain predetermined or assumed figures.

Loads Suited to Various Soils

It is evident that the weight that can safely be placed on a given area of earth, say a square foot, will vary according to the firmness of the soil. Thus, bed-rock will have greater supporting power than moist clay, and clay in turn will be better than silt or quicksand. The load that one square foot of earth will safely support is termed its bearing power. The following table shows the loads that may safely be put upon various kinds of soil:

Nature of Soil.	Bearing Power, Tons per Sq.Ft.
Rock, thick layers	200 or over
Rock, soft	18 or over
Clay, thick beds, dry	4 to 6
Clay, thick beds, moderately dry	2 to 4
Clay, soft	1 to 2
Gravel and coarse sand	8 to 10
Sand, compact	4 to 6
Sand, clean	2 to 4
Alluvial soils	½ to 1

Under ordinary conditions, the loading of an engine foundation based upon rock will never approach the bearing power of the rock. But in cases where there is no rock for the footing, the soil should be examined and a safe bearing pressure should be estimated.

In preparing to build an engine foundation, it is necessary to excavate to a greater or less extent, depending upon the size and type of engine and the nature of the soil. The depth to which the digging is carried may vary from 2 to 20 feet. In any case, the depth must be such that the footing of the foundation will not be affected by frost, and care must also be taken to investigate whether the weight of adjacent structures on the same soil can affect the proposed foundation.

Generally speaking, the foundation of a horizontal engine does not need to be as deep as that for a vertical engine of equal power. The horizontal engine, because of

its form, occupies a greater area of surface than the vertical type and consequently the pressure per unit of area will not be so great, and it will not be necessary to go so deep to obtain a firm footing.

Above all, an engine foundation, or that of any moving machine, should be built independent of the walls of the building in which the engine is to be housed. For, if there is any connection between the foundation and the wall, the repeated shocks due to the motion of the engine will affect the wall, and if they are of considerable intensity may permanently injure the wall.

Kind of Material to Be Used

The kind of material to be used in the construction of a foundation will depend somewhat upon the locality and the materials available. Perhaps the most commonly used material is brick, although concrete has been employed to a large extent and continues to grow in favor. In some instances dressed stone has been used, but this is exceptional because of the increased expense over the cost of brick or concrete. In building a foundation of brick or stone, the mortar used should be made of cement and not of lime, because lime mortar will crumble under the effect of repeated vibrations and will thus allow the foundation to disintegrate.

In case a power station is to be built on very soft earth, as, for instance, along the bank of a river, where silt or quicksand may be encountered, it may be utterly impossible to dig deep enough to reach solid earth for a footing. When such conditions are met with, it is necessary to provide a footing of piles, made of logs driven down into the mud or sand under heavy blows. These piles may be driven deep enough so that their lower ends are embedded in the firmer subsoil. In such cases the supporting power of the piles is very great, because, owing to their being supported laterally by the surrounding earth, they cannot buckle, but will fail by the actual crushing of the material. In other cases the piles do not touch solid bottom, but derive their supporting power from the friction between the surfaces of the piles and the soil in which they are embedded. They are placed in rows and so spaced as to be from 2 to 4 feet apart, measured from center to center. After the necessary number has been driven, the tops are sawed off in a level plane and a grillage composed of heavy timbers and planking is fastened to the projecting tops by means of iron pins extending through the timbers into the heads of the piles. On this planking the masonry foundation is then built up. Fig. 1 shows a construction of this character. The piles *a a* are driven into the soil *b* and sawed off level to receive the cross-timbers *c c* on which the planking *d* is fastened. Upon this there is placed a layer of concrete *e*, and then the brick foundation *f*. Some engineers object to building a plank surface for the lower courses of masonry to rest upon, basing their objections on the statement that there is then no bond between the two, and consequently danger of the superstructure sliding on its footing. This is a remote contingency, however, owing to the friction between wood and stone. Moreover, it may be guarded against by driving rods into the timbers and permitting them to project upward into the concrete and masonry.

Another way of arranging the piling and the concrete is illustrated in Fig. 2. Here the grillage is entirely dispensed with, and the concrete *a* is rammed into place over and between the ends of the piles *b b*. In this way the pressure due to the masonry *c* and its load is not carried wholly by the piles but also to some extent by the soil *d* on which rests the concrete between the piles. At the same time, all danger of slipping laterally is removed because the tops of the piles are imbedded in the concrete. The distance that the piles project above the ground before the concrete is put in may be as much as a foot, and the thickness of the bed of concrete *a* may be from 2 to 8 feet, according to the weight it must support.

What to Guard Against

Attention has already been called to the inadvisability of building a foundation on any soil that will transmit vibration to adjacent property. Especially must this be guarded against when solid rock is encountered in excavating for the foundation. To build directly upon the rock would be to insure the transmission of shocks to whatever adjoining structures were built on the same rock footing. To obviate this difficulty, it is necessary to place some strong yet yielding material between the foundation and its footing. Rubble and timber construction have both been tried, but have been found wanting. Sand in a layer two or three feet deep between the foundation and the rock, and so held by some form of retaining wall that it cannot squeeze out under pressure, has been found to accomplish the desired end, while the use of the same material around the foundation, between it and the sides of the pit, has proved to be advantageous. Another method of preventing vibration from being communicated to other points is to place a thin layer of asphalt between the foundation and its footing. Still further, there are cases on record where the foundations of high-speed engines have been kept from contact with bed-rock by interposing a couple of inches of sawdust, thus effectually preventing vibration from being transmitted.

When bricks are used as the foundation material, they should be of a good, hard quality and should be laid up with a mortar composed of portland cement and sand. The mortar joints should be thin, so that the bricks come quite close together. One part of cement to two of sand will give a good mortar, and the mixing should be done dry, after which small portions may be wetted, as needed. With a brick foundation it is customary to use capstones on which the bed-plate of the engine rests directly. The load is thus distributed with greater uniformity over the foundation.

Stone is often used as the foundation material when brick is not obtainable. A stone foundation should be made of cut-stone and not of rubble masonry, since the latter does not have the firmness and cohesive quality necessary to resist continued vibration and shock.

Concrete is also being used to a great extent in building foundations. The first step is to construct a wooden mold or casing, the inside of which has the form of the foundation to be constructed. This casing is open at the top and bottom, and is placed in position on the footing for the proposed foundation. The concrete is then dumped into the casing and thoroughly tamped. Care should be taken to put in the concrete in quantities forming layers of about 6 inches in depth, each layer being properly rammed into place before the next one above it is put down. After the concrete has set, the casing may be removed, leaving a solid one-piece foundation of the required form. The concrete used for this purpose should be made by mixing portland cement, sand and broken stone in the proportion of 1 to 2 to 4, respectively. The stone should be crushed fine enough to pass through a ring 2 inches in internal diameter.

Losses of Efficiency in Steam Turbines

The best results that have been obtained from large turbines show that about 70 per cent. of the available energy in the steam is converted into brake horsepower, according to Hon. C. A. Parsons in a paper read before the Royal Institution of Great Britain. The chief losses of efficiency in all steam turbines are due to three principal causes: firstly, to skin-friction of the steam coursing at high temperature through the small openings between the blades; secondly, to unavoidable leakages; and, thirdly, to eddy-current losses arising from insufficient blade velocity and errors of workmanship.

The loss due to the friction of the steam in a turbine is reduced by superheating, and thus partially removing the fluid frictional loss arising from the drops of condensed water mingled with the steam. In some cases this gain in efficiency is worth the extra cost of the superheater, but, unless intermediate superheaters are used, initial superheat cannot be raised high enough to maintain dryness throughout the major part of expansion without destroying the turbine.

The Action of Steam During Expansion

Why Steam Exerts Pressure; Why Pressure Varies with Volume and Temperature; Isothermal and Adiabatic Conditions Explained

BY FRED R. LOW

Suppose a pound of steam at a pressure of 120 pounds absolute to be contained in the cylinder, Fig. 1. When we say "at a pressure of 120 pounds absolute," it is meant that upon every square inch of the interior surface of the cylinder there is exerted a pressure of 120 pounds, just as though each square inch of that surface supported a column of water some 276 feet high. What makes this pressure? They will tell you that it is "the elastic force" of the steam, which is well enough for a general answer, but what is this elastic force and how does it produce the same effect in pressures that a heavy weight would do?

We have, in the last lecture*, followed a pound of water from the point at which it first became a liquid, melting from its solid form of ice, to its complete conversion into the vaporous or gaseous state of steam. We have seen it to consist of

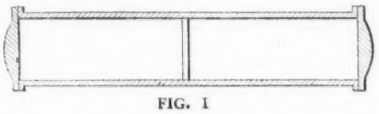


FIG. 1

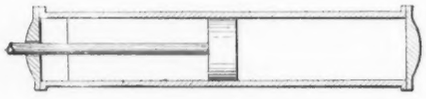


FIG. 4

molecules, held in rigid relation with each other in the solid state by the preponderance of the effect of their mutual attraction; moving freely among themselves in the liquid state, where the attractive force is practically balanced by the centrifugal force due to their greater motion; and darting about violently in the gaseous state, where the centrifugal force has burst the bonds which hold them together, and each molecule goes off at a tangent and at an inconceivable velocity, to continue in a straight line until deflected by contact with some other molecules, either of the steam or of the containing vessel. We have seen, too, that what we recognize as temperature is the kinetic energy, the momentum, the *vis viva*, the energy necessary to get the molecules into motion and stored in their mass in motion.

We have, then, in this box a pound of molecules upon which, since they were released from their fixed positions in the ice at 32 degrees, there have been expended 1185.9 British thermal units, equivalent to

$$1185.9 \times 778 = 922{,}630 \text{ } ft.\text{-}lbs.$$

of energy, enough if it were converted into the potential energy of position to raise the pound to a hight of nearly 187 miles, or if all converted to the kinetic energy of motion, to get up a velocity of over 462,000 feet, or nearly 90 miles per minute. As we have seen, that portion of this energy which affects the temperature has been converted into the latter kind, the energy of motion, while the rest has been expended in lifting the molecules away from each other against their mutual attraction.

We have here, then, a box or cylinder full of molecules flying about in a state of violent activity and containing 922,630 foot-pounds of energy more than they had as water at 32 degrees.

It is the impact, the bombardment, of these molecules which produces the pressure upon the walls which retain them.

Remember that the walls are themselves composed of molecules, already separated from each other by distances vast, as compared with their own diameters, and in a state of rapid motion, but about fixed centers. When the steam is admitted the cylinder is at the temperature of the room, that is to say, its molecules are moving at such a rate that the energy due to their mass in motion produces the impression upon our senses and our thermometers of, say, 70 degrees.

Enter to them the steam molecules, rushing with the velocity corresponding in connection with their mass to 341 degrees. Well, you know what happens when a swiftly moving body comes into contact with a slowly moving one. The swiftly moving one is slowed down and the slowly moving one is hurried up. In any case the combined energy of the pair after impact is the same as that before impact. In the case of bodies composed of molecules, some of this energy may be converted into molecular energy, in changing the shape or raising the temperature of the colliding bodies, but in the case of molecules themselves there is no place for the energy to go to except in preserving the velocity, the momentum, of the colliding bodies. The molecules on impact, therefore, act as perfectly elastic bodies, the energy and the velocity of the common center of gravity remaining the same after as before impact.

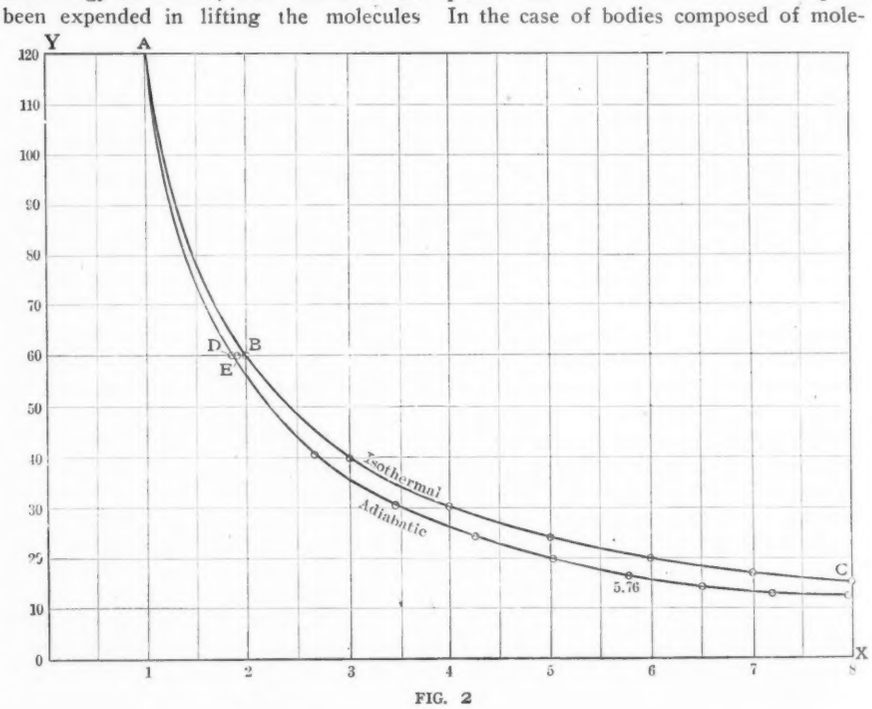


FIG. 2

At first, as we started to say, the incoming steam molecules find themselves inclosed by a wall consisting of iron molecules, moving with considerable less energy, less momentum, than they are themselves. A steam molecule coming into collision with an iron molecule there

*"Physical Properties of Saturated Steam." By Fred R. Low. POWER, September, 1907, page 583.

fore, recoils from the impact with a diminution of its velocity (some of which has gone to increasing the velocity of the iron molecule), and thus of its energy, its temperature. But since, as we are dealing with dry saturated steam, the steam molecule had only just enough velocity to enable it to break free from the attraction of its fellows, and change from the liquid to the vaporous state, it will now fall again under the influence of that attraction and the phenomenon of condensation will take place, and will occur until the molecules of the iron have absorbed enough energy from the steam so that they will be moving with the same momentum or energy that the steam molecules are; in other words, until the temperature of the iron equals that of the steam. After that, since the energy of motion of each molecule is the same, a steam molecule will get as good as it gives when it encounters a molecule of iron, and be batted back with the same velocity with which it approaches and im pacts. Since the steam molecules all have the same mass and velocity, it is equally true that they will rebound from accidental contact without loss of velocity or energy. In order to avoid the complications due to the exchange of heat between the steam and the cylinder walls, let us assume that no such transfer take place, i.e., that the cylinder is composed of a material impervious and insensible to heat, capable neither of absorbing it, transmitting it, nor giving it out.

We have, then, in Fig. 1, a cylinder full of molecules bounding back and forth between the containing walls without loss of velocity, preserving by their bombardment a pressure of 120 pounds on each square inch of the surface.

This steam we are imagining confined to the right of the partition, the space to the left of which is entirely void, a perfect vacuum. Imagine now the partition to be removed and the volume of the steam to be doubled. A molecule would have twice as far to travel between the heads, and at the same velocity could impact only one-half as often as it bounced back and forth lengthwise of the cylinder. Crosswise, or shellwise, there is twice as much surface exposed as before so that with the same number of molecules acting at the same velocity only one-half can impact on a unit of surface in a unit of time. As the pressure is proportional to the number of impacts per second, reducing these impacts one-half reduces the pressure in the same ratio, and since doubling the volume halves the number of impacts per unit of time, when the velocity is kept constant, so doubling the volume halves the pressure when the temperature is maintained constant.

This law was discovered independently by Boyle, in 1662, and by Mariotte, in 1679, and is referred to by the name of either. The above consideration shows the rationale of the law and the conditions under which it may be expected to hold. If there is any tendency to condensation and re-evaporation, the number of molecules acting will be varied, so that this mode of variation is true only of those gases which are far enough above the boiling points of their liquids not to have their integrity as gases affected by the pressures involved.

If the pressure is halved when the volume is doubled, if when the volume is increased to three of the original the pressure is one-third of the initial, and, in general, if the pressure varies inversely as the volume, the product of the volume and the pressure will be constant. Starting with one volume at 120 pounds we should have the following relations:

$p \times v =$	*constant*
$120 \times 1 =$	120
$60 \times 2 =$	120
$40 \times 3 =$	120
$30 \times 4 =$	120
$24 \times 5 =$	120
$20 \times 6 =$	120
$15 \times 8 =$	120

This can be represented diagrammatically as follows:

Draw a vertical line oY, Fig. 2, and lay out upon it 120 pounds to any convenient scale. The cöordinate paper, which may be obtained from any dealer in drawing materials, and ruled as shown, is very convenient for this purpose. Upon a horizontal line oX, at a hight corresponding to the o of the vertical scale, set off the equal spaces 1, 2, 3, etc., to represent volumes. The rectangle $o\ Y\ A\ 1$ represents, then, 1 volume at 120 pounds pressure, absolute, the zero of the scale being the absolute zero, or the indication of the ordinary gage minus the atmospheric pressure, or the reading of the barometer. If,

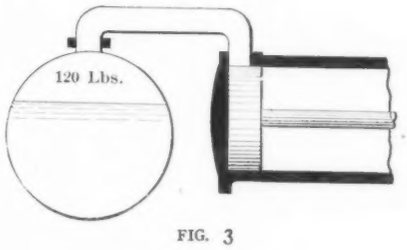


FIG. 3

now, the volume be doubled, the pressure will fall to 60 pounds, and may be represented by a point, B, on ordinate 2 at the hight 60 of the vertical or pressure scale, and the rectangle o, 60, B, 2 will be of the same area as the initial rectangle, being twice as wide and half as high. The product of the pressures and volumes is constant, so these areas, which are the product of vertical dimensions representing pressures and horizontal dimensions representing volumes, must be constant. Setting off upon the succesive ordinates the pressures corresponding to the respective volumes, and connecting them by a smooth line, we obtain a curve which expresses the relation of volumes and pressure for this mode of expansion.

Energy is the product of pressure and change of volume, or volume generated during the operation under consideration.

Take a volume of air in a cylinder having a movable piston. Expand the air by heating or otherwise. The work done will be, obviously, the average pressure multiplied by the distance which the piston is moved, and by the area of the piston. But the product of the area of the piston and the distance through which it moves is the volume generated, so that the energy is the product of the average pressure, and the volume. This is just as true if the expansion takes place outside of a cylinder, as when a balloon is inflated, as you can readily reason out for yourselves by imagining the balloon expanded in a cylinder and remarking that the work done, when referred to the area of the cylinder, is the same as when the expansion is spherical.

But the area of the diagram $o\ Y\ A\ C\ X$, being the product of its length and its average hight, is proportional to the product of the volume and pressure which that length and hight represents, so that the area $1\ A\ C\ X$ represents the energy derivable from the expansion of the volume $o1$ of steam from a pressure of 120 pounds to a pressure of 15 pounds, and the area $o\ Y\ A\ 1$ represents the energy due to the formation or entrance of the steam at the constant pressure of 120 pounds.

To get this a little clearer, suppose in Fig. 3 the steam space and pipe connecting the engine to the boiler to be full of steam of 120 pounds. If this 120 pounds is to be preserved constant the boiler must make steam as fast as the movement of the piston calls for it. If it does not, the steam between the piston and water line will expand and the pressure and temperature go down. If it makes steam faster than the piston generates room for it, more steam will be crowded into the same volume and the pressure go up. Where a pound of water has been converted into steam (assuming another pound of water forced in in the meantime, to replace it) the piston will have moved so as to generate a volume of 3.67 cubic feet, and if our diagram, Fig. 2, is drawn to represent one pound of steam at 120, this will be the volume represented by $o\ 1 = Y\ A$, and the work represented by the area $o\ Y\ A\ 1$ will be the external work of evaporation, or the work done in a steam engine during the period of admission with the pressure held at 120 equals

$$120 \times 144 \times 3.67 = 63{,}417.6 \text{ } ft.\text{-}lbs.$$

Remember that the condition of this mode of expansion is that the temperature of the expanding fluid shall remain constant. In the dictionary you will find a lot of words with the prefix "iso," indicating identity, equality, the same numerical value :

Isobarometric; having the same barometric pressure.

Isochromatic; having the same color.

Isochronal or Isochronous; uniform or equal in time.

Isoclinic; having equal inclination or dip.

Isodynamic; having equality of force.

Isogonic; having equal angles.

Isometric; having equality of measure.

It is, therefore, quite natural in view of the well-known significance of "thermal," with relation to heat and temperatures, that this mode of expansion should be designated by the word "isothermal," signifying, however, not equal or constant heat, but constant temperature.

Although the conditions of expansion in the cylinder of a steam engine do not fulfil this requirement, the expansion line drawn by the steam-engine indicator for the ordinary engine is found to follow this curve more nearly than any other, so much so that theoretical diagrams are laid out by its use, and it is applied to indicator diagrams as a measure of their accuracy. How can this be when the temperature falls (as the tables explained last month show) from 344.1 to 213 during expansion from 120 to 15 pounds? The explanation is that in the steam cylinder we are not dealing with a constant quantity of steam. The steam, usually containing more or less moisture on its arrival from the boiler, comes in contact with surfaces which have just been exposed to the comparatively cool exhaust, and is condensed upon them so that at the point of cut-off the cylinder contains a mixture of steam and hot water, instead of a volume of dry saturated steam. As the pressure is lowered by expansion this hot water finds itself above its boiling point, and is in part re-evaporated, replenishing the losses in volume due to cooling and condensation, so that the line is raised by this additional volume about as much as it would fall away from the other causes.

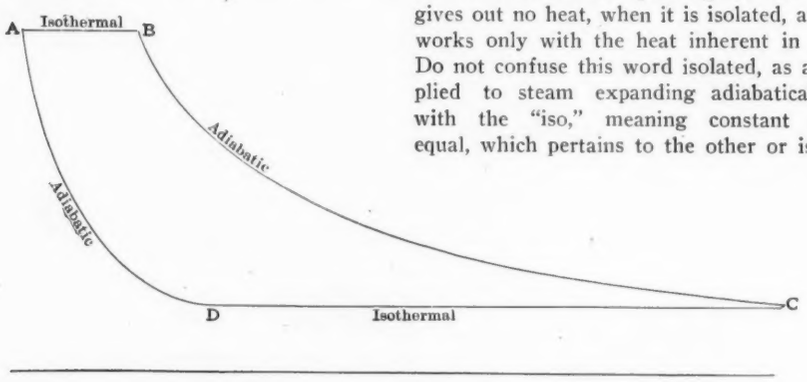


FIG. 5

Adiabatic Expansion

Instead of a cylinder with a vanishing partition, as in Fig. 1, let us consider a cylinder with a piston, as in Fig. 4, and let the steam expand by forcing the piston along.

In Fig. 1 the molecules of steam flying back and forth impact upon unyielding walls which send them back with undiminished velocity. In Fig. 3 those which hit the piston hit a yielding surface which absorbs some of their energy in acquiring its own movement, and they are returned with diminished velocity (temperature), and with a deficit of heat which results in condensation. If it is desired to carry out the expansion isothermally, enough heat must be supplied to the steam as it expands to replace that converted into work, but if the process is conducted without changing the amount of heat in the fluid (except as a portion of it is converted into work), as would be the case in our imaginary cylinder impervious to heat, the expansion will be what is called "adiabatic." This word is made up of the Greek prefix "a," meaning the same as our un, im, non; "dia," meaning through, as dia-meter (through measure); and batos, i.e., to pass—not-pass-throughable. This mode of expansion, then, occurs when the substance expanding receives or gives out no heat, when it is isolated, and works only with the heat inherent in it. Do not confuse this word isolated, as applied to steam expanding adiabatically with the "iso," meaning constant or equal, which pertains to the other or isothermal condition. This is rather a corruption of "insulate," and the prefix thus used has quite another significance. This, the adiabatic, would be the method of expansion of steam in a non-conducting cylinder, and is probably the mode most nearly followed by steam expanding in the steam turbine, where there is little opportunity for heat transfers during the process.

With the cooling and condensation inherent in adiabatic expansion, it is obvious that the volume will be less after a given reduction of pressure than in the case of isothermal expansion. When the pressure is reduced to 60, for instance, instead of having 2 volumes, locating a point on the expansion line at *B*, Fig. 2, for this pressure, the volume by cooling and condensation would have reduced to 1.87, and the line would pass through *D*.

It is possible to lay out curves running above or below the isothermal by making the pressure vary as some power of the volume, the line running above the isothermal when the exponent is less than unity and below when it is greater, as was explained in detail on page 55 of our issue of January, 1907.

The thing to observe and remember about this mode of expansion is that no heat must be added to nor taken from the expanding fluid during the process.

The Saturation Curve

One other curve which is frequently used is the curve showing the relation between pressures and volumes when the steam remains saturated. The values for plotting it may be taken from the steam tables. The volume 0.1 of one pound of 120-pound steam is 3.67 cubic feet; of 60-pound steam, 7.03 cubic feet; so that the horizontal distance at the hight 60, Fig. 2, must be $\frac{7.03}{3.67} = 1.9$ as great as *0 1* or *Y A*, locating the point at *E*, instead of at *B*, where the volume is 2, or at *D*, where it is 1.87. The curve may, of course be plotted directly and easily by laying off a regular horizontal scale for the tabular values for the volumes.

This curve corresponds to no condition met with in practice. The condition may be conceived by imagining heat applied to expanding steam sufficiently to prevent condensation, but not sufficiently to superheat it at any time. From the standpoint of pure theory, the most efficient diagram which a steam engine can make is that shown in Fig. 5, where the expansion is carried adiabatically to the lower pressure and temperature, the diagram ending in a point, and the compression is carried adiabatically to the initial pressure. Obviously the length of the line *A B* is proportional to the new steam required for the stroke and the area of the diagram to the energy derivable, and it will be found that you can get more area per unit of length of steam line in this than in any other way.

The next lecture will make it plain in another way why this should be the most efficient diagram. In the meantime simply notice that this diagram of maximum efficiency consists of two adiabatics, crossing two isothermals.

Canadian Electrical Association

The 17th annual convention of the Canadian Electrical Association was held at Montreal, September 11, 12 and 13. Among the interesting papers which were presented for discussion were the following: "Trials of the Operating Man," by M. A. Sammett; "Three-wire Generators," by B. T. McCormick; "High-tension Insulators from the Engineering and Commercial Standpoints," by Clarence E. Delafield; "The Value of the Nernst Lamp to the Central Station," by A. E. Fleming; "The Load Factor," by R. M. Wilson; "Modern Lighting Transformers," by G. P. Cole.

The entertainment features included visits to the electrical exhibition, to the race track, to the theater and to Dominion park. Altogether it was a highly successful meeting.

Compounding Piston Engines with Turbines

Why the Reciprocating Engine Is the More Efficient at High Pressure and the Turbine Is Best for the Low-pressure Stage

BY PROF. A. RATEAU

In a paper upon the "Development of Exhaust Steam Turbines," presented at a recent meeting of the Society of Belgian Engineers, Professor A. Rateau of l'Ecole Supérieure des Mines of Paris, and inventor of the turbine which bears his name, describes in a lucid manner the advantages of and answers the several objections which have been brought forward to the system of compounding reciprocating engines with steam turbines, of which he has been the foremost exponent. He commences by describing the entropy diagram Fig. 1, drawn for one kilogram of water and from a zero located at 273 Centigrade degrees absolute or at the freezing point of water. The curve *O G C A D H* corresponds to the heating of the liquid from zero to 473 degrees Centigrade absolute. The horizontal line *H I* corresponds to the evaporation at that temperature, and if a point is taken upon that line between *H* and *I* the state of the fluid which is represented by that point is such that the quantities of steam and of water will be represented by the segments into which the line is divided.

At the point *I* the evaporation is complete. If the points at which this condition occurs for different temperatures are considered the curve *I E K M*, which is called the curve of saturation, is obtained. If from the point *I*, where the vapor is in the saturated state, the application of heat is continued, the vapor will become superheated, and the curve *I J* represents this condition.

For adiabatic expansion, as there is no heat communication with the exterior, the entropy remains constant and the representative curve is reduced to a straight line *I P* or *J L*, parallel to the axis of temperatures.

Suppose that we deal with one kilogram of the vapor of water dry and saturated at a pressure of 8 kilograms per square centimeter (113.79 pounds per square inch), which we will allow to expand to the pressure of one kilogram per square centimeter (14.22 pounds per square inch), the ordinary conditions under which the engines of mines and steel works of the older types operate, exhausting freely into the atmosphere. The diagram representing this condition consists of the area *A D E B*, of which the surface is proportional to 82.5 calories. The corresponding theoretical consumption is 7.6 kilograms per cheval-heure (16.99 pounds per horse-power-hour). Let us see what will be the gain obtained by applying the condenser. Assuming an ordinary vacuum of 90 per cent.—that is to say, an absolute pressure in the condenser of 0.10 kilogram per square centimeter (1.422 pounds per square inch)—the cycle is represented by the trapezoid *C A B E B F*, of which the surface is proportional to 155.5 calories. The theoretical consumption corresponding to this condition is 4.07 kilograms per cheval-heure (9.1 pounds per horse-power-hour). A comparison of these figures indicates that the advantage to be derived from such use of a condenser might be 46 per cent. As a matter of fact, using the reciprocating engine the economy realized is not on the average above 15 per cent., and it may be safely said that it practically never reaches 25 per cent.

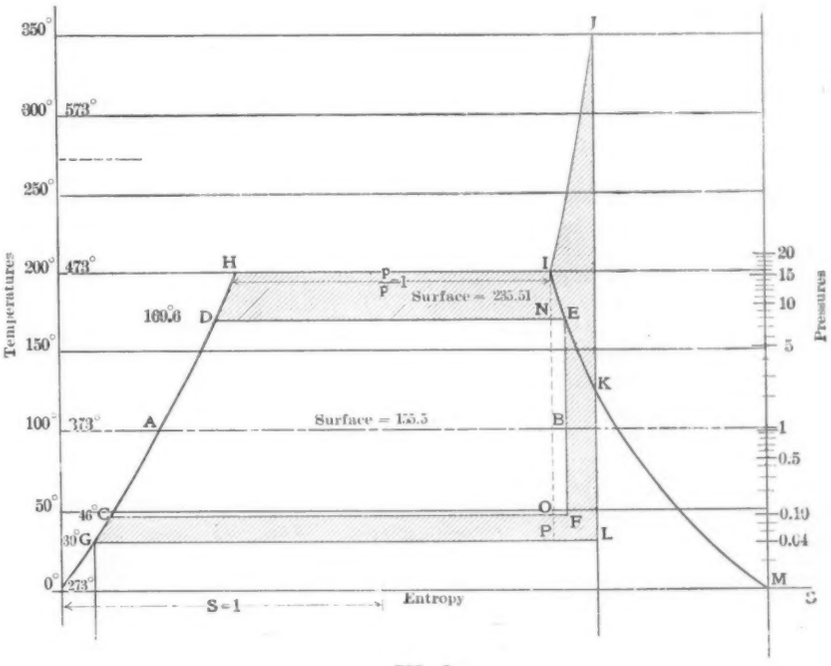


FIG. 1

This considerable difference between theory and practice shows that in the use of steam at low pressure we must submit in the reciprocating engine to important losses which are not involved when steam of high pressure is used. It is easy to account for the fact that reciprocating engines lend themselves but awkwardly to the utilization of low-pressure steam while they give good results on the high-pressure end of the scale. In the latter case the steam is expanded in a cylinder of a relatively small volume; the losses by friction and radiation are at a minimum and the expansion can be carried completely to the limiting lower pressure.

In the case of low-pressure steam the cylinder becomes of immense size, and even then does not permit the achievement of complete expansion. Take the case of an engine of 2000 horse-power, consuming 6 kilograms of steam per cheval-heure (13.416 pounds per horse-power-hour), or 3.3 kilograms (8.38 pounds) for the whole engine per second. The pressure in the condenser being but 0.1 of a kilogram (1.422 pounds), the volume of steam flowing, allowance being made for condensation due to expansion, would be in the vicinity of 40 cubic meters (1412.59 cubic feet per second). Assuming that the piston speed is 3 meters per second (590 feet per minute), it would have to have a diameter of about 4 meters, or 13 feet, to generate that volume. As no such dimensions as these are practicable the expansion must remain incomplete, and any attempt to attain this completion by augmenting the size of the cylinder would result in important losses by friction by reason of the heavy and cumbersome moving parts and by condensation, which would become of increasing importance in cylinders presenting so much surface for the weight of operating fluid passed. There would be further losses from wire-drawing such an enor-

mous volume through any ports which would be practicable.

A reciprocating engine, then, operating at an admission pressure in the vicinity of the atmospheric, would require, in order to utilize all the energy due to expansion to the pressure created by the condenser, dimensions so great that its cumbersomeness, weight and cost of installation would be practically inadmissible for the inconsiderable gain which it would produce in the efficiency; whereas a turbine, on the other hand, permits us to utilize perfectly steam of low pressure and to derive the utmost benefit from the vacuum given by a condenser even of a high degree of efficiency. With the great velocity of flow in a turbine and the immense capacity for discharge which results therefrom, there is nothing to prevent the construction of a turbine capable of utilizing at low pressure a flow of steam of several thousand

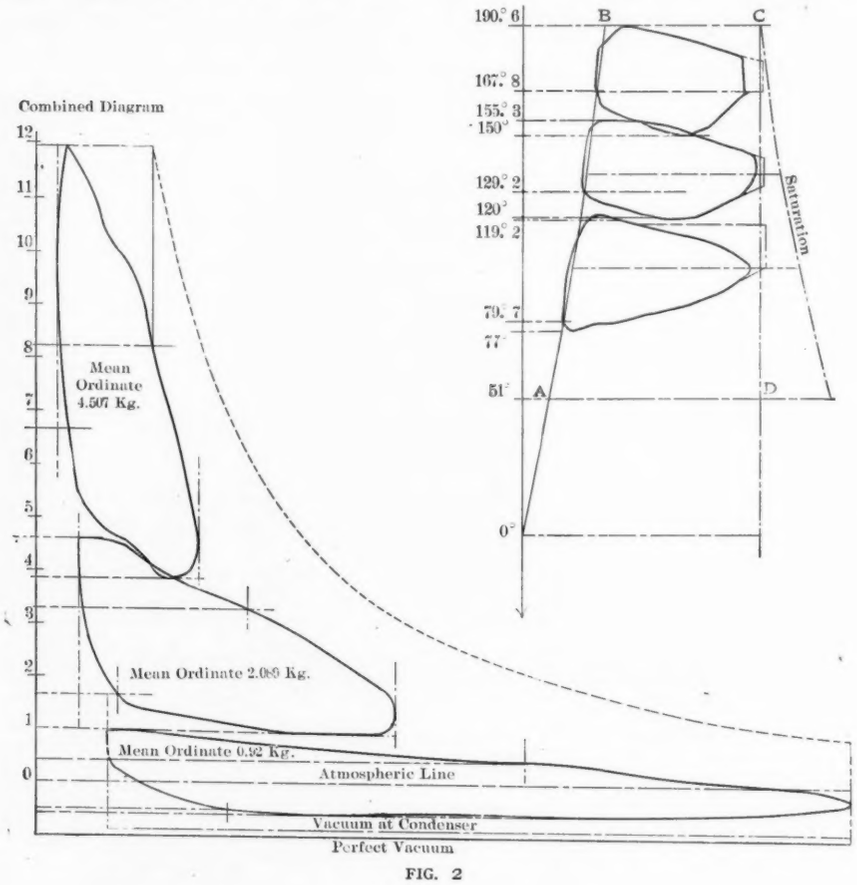


FIG. 2

and even of several dozens of thousands of kilograms per hour, without exceeding very ordinary dimensions.

It is precisely because the turbine utilizes perfectly the expansion of steam of very low pressure that there is so much interest in perfecting the condenser so that it may produce an excellent vacuum, which interest has been hitherto lacking, since with the reciprocating engine it was impossible to make so advantageous a use of the vacuum when produced.

The lower the pressure of the steam the better account the turbine gives of itself. This is due to a diminution of the losses by windage, the vanes moving with less friction in the more attenuated vapor, and to the lesser tendency of the lower pressure steam to leak through the clearances between the moving and fixed members. These two losses being sensibly proportional to the specific weight of the fluid are therefore as much less as the specific volume of the latter is greater.

An excellent illustration of the preceding argument is furnished by the diagrams shown in Fig. 2 plotted from indicator diagrams taken from the triple-expansion engines of the ironclad "Charles Martelle," by Monsieur Long, engineer-in-chief of the Marine Française. The lower figure gives the combined pressure-volume diagram replotted from the actual indicator diagrams, and the upper figure the diagrams redrawn to the temperature-entropy scale. The latter shows very plainly, by the area comprised between the lower line of the lower cycle and the line *A B*, the enormous loss which results principally from the incomplete expansion in the third cylinder. While the work realized by the first two cylinders amounts to about 80 per cent. of that available, only about 45 per cent. of the available energy is realized in the third cylinder, as shown by the relation between the area inclosed by the diagram to that between the line of its initial temperature and the line *A B* of low-temperature limit.

It is true that we are dealing here with a marine engine. In stationary work one is less restricted as to dimensions and weights and the expansion can be carried farther. Even in the latter case, however, the losses under consideration remain very important.

The author cites the Nordberg engine described in a paper entitled "A High-duty Air Compressor," by O. P. Hood, at the November, 1906, meeting of the American Society of Mechanical Engineers (see page 221 of the *Transactions* of that year). The consumption of dry saturated steam of 242.8 pounds near the throttle was 11.23 pounds per horse-power-hour, and an absolute pressure in the condenser of 1.25 pounds. This figure corresponds to 5.20 kilograms per cheval-heure indicated or to 5.75 kilograms per cheval-heure effective, assuming a mechanical efficiency of 92 per cent. The theoretical consumption under these conditions being 3.36 kilograms, the efficiency of the machine is 60 per cent.

The fourth or low-pressure cylinder works entirely below the pressure of the atmosphere, with an admission pressure of 0.945 kilogram per square centimeter (13.44 pounds absolute) under the same conditions therefore as our low-pressure turbine. It gives 275.5 indicated horse-power in a total of 990, being 28 per cent. only of the total, while according to the entropy diagram it ought to do 37½ per cent., and even more, on account of the re-heating receivers, from which it appears that the work realized by the fourth cylinder does not reach 45 per cent. of the possible, while that of the three preceding cylinders is in the neighborhood of 70 per cent. Mr. Hood's paper gives the entropy diagram of the machine, reproduced in Fig. 3, and it is strikingly shown how the efficiency of the fourth cylinder is affected by the failure to realize complete expansion.

Let us return to the entropy diagram, Fig. 1, and see what results can be obtained by using successively a reciprocating engine and a turbine in order to obtain a complete expansion from the initial to the condenser pressure. In order to obtain the best conditions, we will choose a reciprocating engine of the two-cylinder compound or even triple-expansion type, assume a high initial pressure, a very good vacuum and superheated steam within the limits which have been found practicable in actual work. Let the initial pressure be 16 kilograms per square centimeter (227.57 pounds per square inch), the temperature corresponding with which is 200 degrees Centigrade (392 Fahrenheit). We will find that the area has been augmented by raising the pressure from 8 to 16 kilograms per square centimeter, some 16 per cent. With a first-class condensing apparatus, such as is available at present, giving a vacuum of 96 per cent., with a corresponding temperature of 30 degrees Centigrade (86 degrees Fahrenheit), the diagram is further augmented in area some 14½ per

cent. Further, if we use steam superheated to 350 degrees Centigrade (662 degrees Fahrenheit), the area of the diagram will be further augmented 21 per cent. The curve of superheat, *I J*, in Fig. 1, has been calculated by the use of the coefficients of specific heat of superheated steam determined by Knoblauch and Jakob. The theoretical consumption per cheval-heure corresponding to these conditions is 2.67 kilograms (5.97 pounds per horse-power-hour), and the total surface of the entropic cycle *G H I J K L* 235.5 calories.

Comparing the two extreme cycles which we have considered, the cycle *C D E F* corresponding to an initial pressure of 8 kilograms and a condenser pressure of 0.10 kilogram without superheating had an area proportional to 155.5 calories, the total number of calories furnished to one kilogram of the liquid being 612.4, the efficiency is

$$\frac{155.5}{612.4} = 25.4 \text{ per cent.}$$

With the later cycle, realizable today, the number of calories furnished is 712.9, the area of the diagram being 235.5 calories, and the efficiency rises to

$$\frac{235.5}{712.9} = 33 \text{ per cent.}$$

Let us consider now the final result of this utilization. The efficiency of high-pressure reciprocating engines reaches nearly to 80 per cent., the relation of the energy applied to the shaft to the energy theoretically available, and this efficiency is also obtainable with the low-pressure turbine. In order to be conservative we will take an efficiency of 76 per cent., only, for both cases, in which case we shall utilize $0.33 \times 0.76 = 25$ per cent. of the heat transmitted to the water. This is a result comparable to those which have been obtained with gas engines. The steam consumption would be 3.5 kilograms per cheval-heure effective (7.826 pounds per horse-power-hour), or approximately 5 kilograms (11.023 pounds) per kilowatt-hour. But it is yet possible to realize another economy in effecting an exchange of heat between the steam which has already done work, and the water which is returned to the boiler. Some 8 per cent. can be gained in this way, so that a final consumption of 2300 calories per cheval-heure effective, corresponding to 3.22 kilograms (7.2 pounds per horse-power-hour) is attainable. This is practically identical with the result obtained with gas or oil engines of the most improved design and construction, and all this can be accomplished under conditions easily realized with apparatus already in daily use.

Objections

The author of the paper thus proceeds to consider some of the objections which have been urged against the system.

1. It has been said that there is no advantage in effecting the condensation by the intermediary of a turbine rather than directly on the primary engine. This amounts to the same thing as saying that the result would be the same whether the expansion is carried out in the cylinder of a reciprocating engine or in a turbine. That this objection will not stand analysis will be seen by what has preceded. If the condenser is applied directly to the primary engine, the efficiency attained will be far less than that which we might reasonably expect. Instead of an efficiency of 46 per cent. that we should have in the preceding example, we should not attain more than 15 per cent., by reason of the inaptitude of the simple reciprocating engine to utilize steam in the lower pressure stages. With a turbine, on the contrary, there may be obtained without difficulty a duty which is nearly double that of the third cylinder of a triple-expansion reciprocating engine.

Some figures will render this comparison more clear. Let us take for example the case of a rolling-mill engine, consuming 20,000 kilograms (44,092 pounds) of steam per hour and exhausting into the atmosphere.

The advantage to be gained by the addition of a condenser, being on an average some 15 per cent., would represent 3000 kilograms (6614 pounds) of steam per hour. Let us use this steam at high pressure for making electricity. It would be necessary to count upon 10 kilograms (22.05 pounds) per kilowatt-hour, so that we should obtain normally 300 kilowatts or about 450 effective horse-power.

Assuming even that it were possible to gain 25 per cent. by the application of the condenser, this would amount to only 500 kilowatts or 750 effective horse-power.

If on the contrary we use a turbine and we again allow 15 per cent. of gain by the use of the condenser, the steam furnished per hour to the turbine would be 17,000 kilograms. Assuming a maximum consumption of 17 kilograms (37.48 pounds) per kilowatt-hour with a vacuum as poor as 88 per cent., we should obtain 1000 kilowatts or 1500 effective horse-power. There is a result at least double, nearer triple, than which one would attain in using the steam economized by condensation directly in a high-pressure engine.

2. Another objection is based upon the counter-pressure produced upon the primary machines when their exhaust is conducted to the accumulator. It is true that the back pressure is somewhat increased, but it should be remarked that this increase is very small, not more on an average than 0.2 of an atmosphere; so little that in fact the effect is not noticeable upon the primary engine either in capacity or efficiency.

But it is not at all necessary for the application of the system that the pressure in the accumulator should be superior to that of the atmosphere. If desired, the pressure may be carried a pound or more below that of the atmosphere and benefit to that extent the primary motor. Even then it will be very advantageous to employ an exhaust steam turbine, for one can still obtain a great deal of power from this low-pressure steam by the use of a good condenser. Suppose for example that the steam could be expanded in the turbine from a pressure of 0.5 of a kilogram to that of 0.08 of a kilogram per square centimeter. One could then produce a kilowatt with 21 kilograms of steam (only 15.5 kilograms per cheval-heure), assuming that the efficiency of the turbine did not exceed 65 per cent. It will be seen therefore that the use of the turbine still presents a considerable advantage even in the case where it is indispensable that back pressure shall be avoided.

This is not, however, generally the case, and we advise some back pressure upon the primary machine. This results in a double advantage, first the leakage of air at the joints, stuffing-boxes, etc., of the primary machine is avoided, leakage which is disadvantageous to the best operation of the condenser, and secondly an increase of the efficiency of the combination results from raising as high as possible, within limits, the intermediate pressure between the two machines, and this because the turbine, as I insist again, utilizes low-pressure steam to much better advantage than the reciprocating engine. Contrary to what might be believed at first glance, there is no disadvantage, and in fact is an advantage, in raising the counter-pressure upon the primary machines to a point where it begins to affect their capacity prejudicially.

3. It has been urged against the system that it increases the loss by condensation due to radiation from the accumulator and the pipes by which it is connected. The importance of this factor is very small, as it is easy to verify.

The total amount of moisture contained in the steam—it is easy to measure this since it is discharged at the overflow—amounts on an average to 15 per cent., sometimes greater and often less. The greater part of this water of condensation is not due to radiation from the accumulator, but comes from radiation in the primary machines and the piping of these machines, and above all to the work done by expansion. The radiation of the accumulator does not add to this more than one or two per cent., at the most. We can easily calculate it. It is well known that the quantity of steam at 100 degrees Centigrade (212 degrees Fahrenheit) condensed by radiation by bare iron surfaces is in the vicinity of one kilogram per square meter, and per hour, and that that quantity is reduced at least one-half when the iron surfaces are covered with a good non-conductor. We have ourselves verified these figures upon numerous occasions. According to this, for an accumulator of considerable size having 250 square meters of exterior surface and

cubic capacity enough to regulate a flow of from 10,000 to 20,000 kilograms of steam per hour, the quantity of water condensed per hour would not exceed 125 kilograms, which is about 1 per cent.

But little importance can therefore be attached to this objection.

4. Let us examine, now, a singular criticism which has been urged against this system. They say that one has not always a use for the power produced. It is very evident that if one has need of nothing there is no necessity of applying any system whatever. But in practice such a case would be very exceptional. A use will always be found for the power produced, principally in making electricity, which can serve to replace some of the steam engines.

possible use about the works for the power produced, since electricity permits a transportation of energy to considerable distances, it will be generally practicable to utilize this power in other localities. At a mine, for instance, the exhaust from steam hoists may be used to generate electricity to operate electric hoists at other shafts. An installation of this sort has been made at the Hucknal-Torkard colliery, and others of a like nature are also in course of construction.

And finally one could even sell the energy produced. Applications of this nature have already been undertaken, for example, in England, where they have commenced purchasing exhaust steam for this purpose.

5. Another criticism of the system relates to the employment of the reducing valve in the case where it is necessary to feed the turbine with live steam coming directly from the boiler. It is certain that this practice has the disadvantage of not utilizing all the energy contained in the live steam; but, as we shall soon see, the loss which results therefrom is of small importance and it is easy to avoid this loss completely by the addition of a high-pressure turbine.

expansion without work, it will be seen that the relative loss is finally only 2 per cent., which is insignificant. In most cases the turbine is supplied at the same time by machines which operate continually, so that the loss will be still less important. But it might be desired to utilize the turbine even when the primary machines are not running, at night for example. In such a case the use of a reducing valve would not of course be advisable, and the idea at once suggests itself of installing a group composed of a high-pressure turbine and a low-pressure turbine by means of which all the energy contained in the live steam from the boilers and in the exhaust steam from the reciprocating engines can be utilized.

6. Two criticisms have been made of the operation of the accumulator itself. It is pretended that its efficiency will diminish little by little by reason of the accumulation of the oil contained in the exhaust steam. It is true that a coating of oil forms on the plates of the cast-iron type of accumulator, but this does not interfere sensibly with the exchanges of heat. The apparatus at Bruay has been in operation for five years without any noticeable change in its efficiency. In the accumulator where the water mingles directly with the steam, the oil which is entrained by the exhaust accumulates so that little by little the proportion of oil in the water augments, but this does not interfere with the operation of the apparatus, on account of the movement of the liquid. During the periods of inactivity the oil arises to the surface and forms a

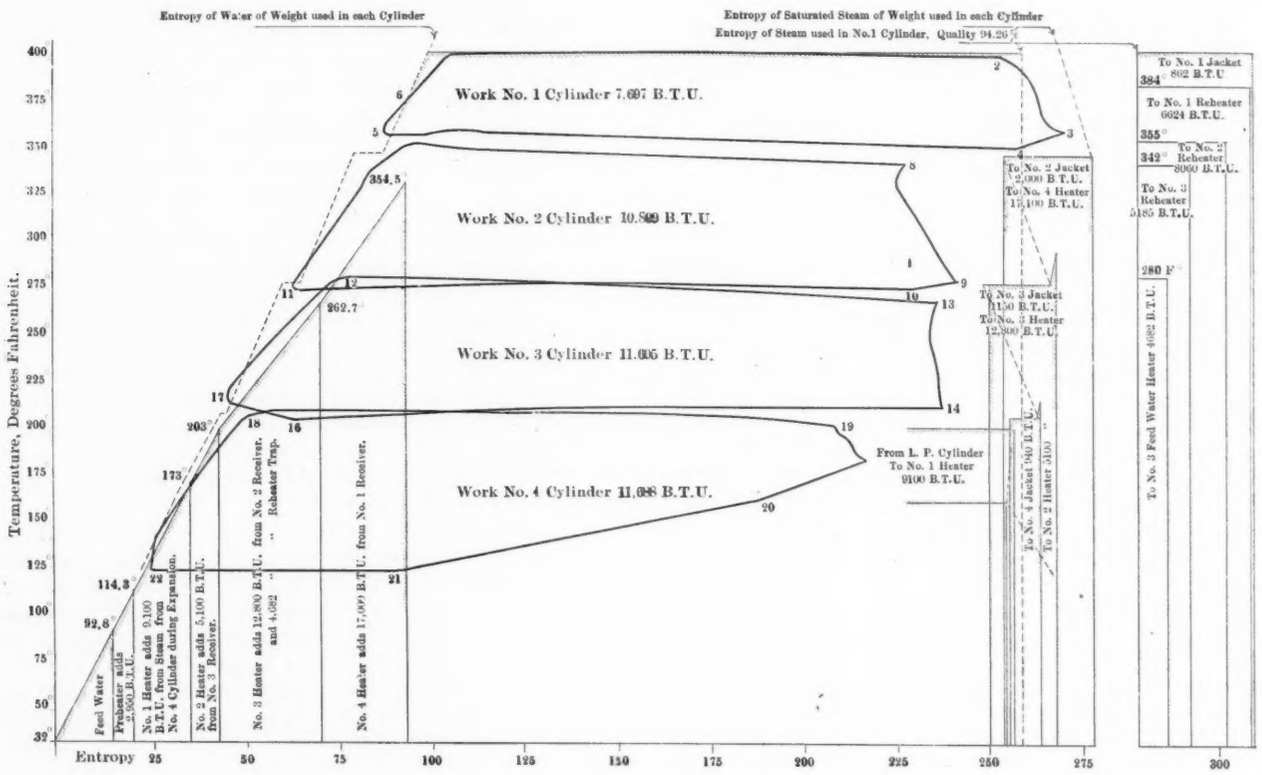

Entropy of Water of Weight used in each Cylinder
Entropy of Saturated Steam of Weight used in each Cylinder
Entropy of Steam used in No.1 Cylinder, Quality 94.26%
Temperature, Degrees Fahrenheit.
Entropy
Work No. 1 Cylinder 7,697 B.T.U.
Work No. 2 Cylinder 10,849 B.T.U.
Work No. 3 Cylinder 11,035 B.T.U.
Work No. 4 Cylinder 11,088 B.T.U.
To No. 1 Jacket 892 B.T.U
To No. 1 Reheater 6624 B.T.U.
To No. 2 Reheater 8060 B.T.U.
To No. 3 Reheater 5185 B.T.U.
To No. 2 Jacket 2,000 B.T.U.
To No. 4 Heater 13,100 B.T.U.
To No. 3 Jacket 1150 B.T.U.
To No. 3 Heater 12,300 B.T.U.
From L. P. Cylinder To No. 1 Heater 9100 B.T.U.
To No. 4 Jacket 940 B.T.U.
To No. 2 Heater 5100
To No. 3 Feed Water Heater 4982 B.T.U.
Feed Water
Preheater adds 2,500 B.T.U.
No. 1 Heater adds 9,100 B.T.U. from Steam from No. 4 Cylinder during Expansion.
No. 2 Heater adds 5,100 B.T.U. from No. 3 Receiver.
No. 3 Heater adds 12,800 B.T.U. from No. 2 Receiver, and 4,982 " Reheater Trap.
No. 4 Heater adds 17,600 B.T.U. from No. 1 Receiver.

FIG. 3

It is not necessary, however, to produce electricity; the utilization of the exhaust steam may be undertaken for other ends. In mines, for example, air may be compressed, in which case it would be preferable to use turbine compressors of the multi-cellular type, with which it is possible to attain with good efficiency compressions up to 10 atmospheres. An application of this sort has already been made by us at the mines of Béthune, where a turbo-compressor of 350 horsepower capacity has been at work for a year, and many others are in process of manufacture. Or again, a turbine operating by exhaust steam may be coupled to a centrifugal pump, which may serve any of the various purposes for which such pumps are used, even for the feeding of the boilers. And, finally, if there is no

coating which can be drawn off from time to time by means of the blow-off valve. The accumulator fulfils in this way to some extent the office of an exhaust-steam purifier. The second criticism is that in the accumulators where the steam is discharged through small openings into the body of water, the perforations will become obstructed by scale and impurities in the water. There is certainly no reason to expect such a result, since, once the apparatus has been filled, all the water which comes through it is water which is formed by the condensation of steam, that is to say, distilled water. As a matter of fact, however, no such effect has been observed.

Comparison of the System with the Use of Electric Motors

It appears to me to be worth while in conclusion to establish a parallel between that which can be realized by means of the process which we have been considering and that which is being obtained today with electric hoisting machines or with reversible electric motors applied to rolling mills. The results of tests of the latter machines have been published from many sources, notably by E. F. Paul Habets, in an interesting communication presented in June, 1906, before the Societé de l'Industrie Minerale, at Paris. According to the information here furnished the consumption of steam by the operating engine was on an average 15 kilograms per hour and per cheval effective (33.54 pounds per horse-power-hour) in coal elevated in the shafts for a period of 24 hours, the operating steam engine being fed with superheated steam at high pressure. According to circumstances more or less favorable, this consumption may vary from 12 to 17 kilograms, or even to 18 kilograms per hour, and per cheval effective, produced for a machine of considerable importance.

Now let us see that by compounding reciprocating machines with turbines it is possible to arrive at results analogous and even better. Let us examine first the case of the hoisting engine of the old single-cylinder type, without variable expansion. The consumption of steam is considerable, 50 kilograms per cheval-heure effective (111.8 pounds per brake horse-power-hour), for example. Let us add an exhaust-steam turbine which will receive in the vicinity of 42½ kilograms of steam for each 50 kilograms consumed by the primary machine, 15 per cent. being lost by reason of condensation. If we assume for the turbine a consumption of 12 kilograms per cheval-heure, the utilization of 42½ kilograms of steam will furnish 3½ horse-power and the final result for the combination will be 4½ horse-power for the original consumption of 50 kilograms of steam. In other words, the consumption of the combination of reciprocating engines and turbines will be 11 kilograms of steam per cheval-heure effective.

If we had assumed that the turbine alone would consume 15 kilograms per cheval-heure effective, which would correspond to a very small machine or one with but a partial load, the consumption of the combination would still be no more than 15 kilograms instead of 11.

Now let us take the case of a good modern compound, such as is constructed today, furnished with steam at high pressure. The consumption of steam per cheval-heure effective could be reduced certainly to less than 20 kilograms, although without condensation. By adding an exhaust-pressure turbine consuming 12 kilograms per cheval-heure, the consumption of the combination would be reduced to 8¼ kilograms of steam per cheval-heure effective. If it is assumed that the primary machine is fed by superheated steam and that its consumption still remains at 20 kilograms, the consumption of the combination will not be more than 7½ kilograms, since there will not be so much condensation before the delivery of the steam to the turbine.

These figures have in them nothing of the absolute; in practice they will vary according to circumstances and can but give a general idea of the possibilities of the subject. Perhaps the following demonstration will be more striking: Let us consider what results can be obtained in the case of an installation of engines operating independently, producing an average of 500 effective horse-power, which would be the case of a reversible rolling-mill engine.

1. Let us consider a compound engine operating with high-pressure steam a little superheated and exhausting at the pressure of the atmosphere. Its hourly consumption for an average load of 500 horse-power need not be estimated at more than 10,000 kilograms of steam (20 kilograms per cheval-heure effective), the steam being initially superheated would issue from the primary engine without sensible condensation, as has been observed at the steel works of Bombach, and by utilizing these 10,000 kilograms of exhaust steam in a low-pressure turbine, furnished with a good condenser, we would develop in the vicinity of 850 electric horse-power. This assumes for the turbine a consumption of 12 kilograms per cheval-heure, which is perfectly admissible, since it is a result which has been actually exceeded in practice. In this manner we should produce therefore, in addition to the required 500 horse-power, a supplementary power of 850 electrical horse-power.

Now let us see what we could produce with this same 10,000 kilograms of steam by equipping the rolling mill electrically. We may assume, in view of the best published results, that a good modern electrical unit running intermittently would consume at least 12 kilograms of steam per cheval-heure effective, and we must count therefore upon an expense of 6000 kilograms of steam per hour to obtain the 500 horse-power required. Under the conditions assumed above we should require an additional 4000 kilograms of steam, which would allow us to produce at the most 590 electrical horse-power, supposing a consumption in actual service of 6.6 kilograms per electrical horse-power, or 9 kilograms per kilowatt-hour.

In the example shown we obtained 850 horse-power by one system, and only 590 horse-power by the other. The superiority of the first system is therefore evident, and it still remains to take account of the economies of installation, which are very important, for the electrical equipment with reversing motors is very expensive.

It will be seen therefore that the proposed system permits not solely the considerable improvement of old installations, but the putting down of new plant in a manner which will allow it to give a much better efficiency.

It cannot be denied that it is generally convenient to group in a single station all the power-producing machinery, but it should be recognized on the other hand that this concentration is not without its disadvantages. In the case of a serious accident at the central station the service will be completely disorganized, and further for large works, such as those in the steel and iron industries, where the power is created at the point of application, there is no marked advantage in grouping all the motive machines in the same building.

I am inclined to think therefore that it would be somewhat premature to accept as a positively progressive step the installation of electric motors for intermittent service. Results at least as good can be obtained with a considerably lower cost of installation by retaining the steam engines and complementing these with exhaust-steam turbines, provided of course that the power developed by the turbine taking all the steam discharged by the primary engine will be immediately utilizable to advantage, which is nearly always the case.

Bursting of Discharge Chest of Air-compressor Cylinder

While a compressor and the attached piping system were being tested recently at the new plant of the Woodruff Ice Company at Peoria, Ill., the discharge chest on the left-hand cylinder burst and badly shattered the ⅝-inch cast-iron water-jacket surrounding the cylinder. The erecting and the operating engineers were both somewhat injured. The gage at the time of the accident showed only 240 pounds, whereas the machine had been tested on the day previous to 300 pounds, and in the shop to 500 pounds. It is, therefore surmised that the fracture was due to an explosion of oil vapor due to the heat generated by compression, there being no circulation in the water-jacket at the time.

Civil Service Examination

POWER readers who recall the remonstrance excited by the attempt of the Civil Service Board to restrict the examinations for chief engineers of post-office and treasury buildings to technical graduates will be interested to read the following list of questions (as he remembers them) sent to us by one who took the last examination, which was held on August 28, 29 and 30, 1907.

First Day, First Paper

Subject: "Mechanisms and Applied Mechanics." Time allowed, three hours.

1. (a) Define velocity ratio; harmonic; cam.

(b) Discuss fully involute and epicycloidal gearing and state the modifications that are required in practice.

2. (a) Give method of laying out step (speed) cones for open belts.

(b) Make a sketch of a Stevenson link-motion, and describe it fully, as well as its advantages.

3. (a) A shaper head is to be designed with a quick-return motion, the head returning in one-third the time it took to travel forward. Plot a cam construction that will fulfil these conditions, and show all your construction lines in detail.

(b) Show a method of laying out bevel gearing.

4. Given the horse-power of a wrought-iron shaft, develop the formula: $Ip - \pi r^2$, and ascertain the diameter of the engine shaft.

5. A chimney is to be erected having 4 feet inside diameter, 6 feet at the top, with a base of 10 feet; the material of construction weighs 125 pounds per cubic foot; the maximum wind velocity equals 35 miles per hour. Required, the safe hight of the stack.

6. A beam 8 feet long is supported at both ends; a uniformly distributed load of 125 pounds per foot length is resting upon the same; also, an additional load of 400 pounds two feet from one end. With a safe stress of 600 pounds per square foot in the beam, calculate the depth of the beam when the width of the same equals two inches. Show all your figures.

First Day, Second Paper

Subject: Same. Time allowed, four hours.

1. Give a complete (report) description of any modern mechanically and electrically equipped building (one of which you have actual knowledge) which does not generate its own electricity. It is desired, in giving this description, that the report shall be as complete as possible, and at the same time not go into too much detail description, using the technical names and usual language in designating the different units and appliances.

2. Give your reasons why monthly reports should be kept, showing the owner the cost of operation, unit cost of supplies, etc.

3. Draw up a description of a chief engineer's report which you would advise having printed and kept, showing the amount of material, supplies, etc., used, the total and unit cost of the same, as well as other data you think would be advisable for such a report.

4. State your reasons underlying your recommendation that a concern purchasing current from an outside company should install its own plant.

Second Day, First Paper

Subject: "Thermodynamics." Time allowed for second day, seven hours.

1. What is meant by adiabatic and isothermal expansion?

2. (a) Two boilers operating at 150 pounds gage pressure, 24 hours per day each, burn 30,210 pounds of coal per day and evaporate 33,364 gallons of water, with an economizer temperature of feed-water at 229 degrees. What is the equivalent evaporation from and at 212 degrees Fahrenheit?

(b) Draw up a set of specifications for a 100-horse-power fire-tube boiler to carry a pressure of 125 pounds per square inch.

3. What is the difference between a gas and a vapor? What is water gas and how is it made?

4. Two cubic feet of steam at 125 pounds gage pressure is expanded to four times its volume, $pv = RT$. Required, the final temperature T, the pressure p and the value of the constant R. The absolute temperature corresponding to 125 gage $= 325.2 + 460$.

5. Explain the construction and operation of a mechanical stoker; give your reasons and state under what conditions you would advocate the installation of mechanical stokers.

6. Draw a diagram of an indicator card taken from the high- and low-pressure cylinders of a compound engine. (a) Name all the different points on the cards, showing approximately the pressures you would expect from the same at different parts of the stroke. (b) Finally show by sketch and explanation the method of *combining* the two cards together. Explain fully.

Second Day, Second Paper

Subject: "General Engineering."

1. A boiler 72 inches in diameter is to be designed to carry 150 pounds per square inch. Pitch of rivets $= 3$ inches and the diameter of each rivet $= \frac{7}{8}$ inch. Required (a) the shearing stress in the rivets (b) thickness of plate (c) efficiency of joint.

2. Describe the difference between a Curtis and a Parsons steam turbine, and state why this type of prime mover shows such a remarkable economy over the reciprocating type of engine.

3. Make a sketch of a Babcock & Wilcox water-tube boiler showing the setting and fittings, etc. State their advantages and disadvantages.

4. (a) In throwing a lump of coal into the furnace state the chemical action which takes place.

(b) What causes smoke?

(c) How can it be prevented?

(d) What is the result if not enough air is supplied?

(e) From an economical standpoint, why is it advisable to prevent smoke?

5. Make a sketch of an hydraulic-elevator engine and drums, and show how the safety devices are attached. When two or more elevators are to be installed, what type would you recommend if floor space were scarce?

6. What is meant by natural portland cement, and portland cement?

7. One room of a building 12x16 feet is to be equipped on one wall with a six-bowl lavatory and on the other two with closets and a slop-sink. Draw a plan and elevation showing the location of the above with all the pipes, valves, etc., in place, especial attention being paid to the soil piping, including re-venting.

8. What is the difference between *direct* and *indirect* heating, and how are the different systems regulated? State the advantages of one system over the other. (a) Give a sketch of a three-story building heated on the one-pipe system, show all radiators and valves in place, and how the water of condensation is returned to the boiler. (b) What is the difference in construction between a boiler for steam and one for heating purposes? (c) What is the difference between a hot-water radiator and one that is used for steam?

9. Plot a valve diagram, using the Zeuner method, with a valve travel of 4½ inches; lead, ⅛ inch; exhaust, ⅞ inch. Give all dimensions in percentage of stroke.

10. Draw a thermostat and show all the valves, etc., and the operation of the thermostat for the control of a hot-water heating system.

11. (a) Explain fully the chemical analysis of bituminous coal; explain fully the apparatus construction for determining the same, with complete method of procedure in carrying out the test, selection of sample, etc.

(b) Give the heating value in B.t.u. of the following coals: Anthracite, pocahontas, Georgia river and western lignite.

12. (a) Describe an efflux tube; define velocity head and pressure head. Explain the phenomenal action of the velocity of efflux.

(b) What causes water hammer in steam pipes?

Third Day, First Paper

Subject: "Electrical Engineering." Only five hours allowed for entire third day.

1. Define fully the following: Hysteresis, Electrolysis, Capacity, Reactance, Impedance, Phase, Leading and Lagging Currents, Self-induction, Frequency.

2. (a) Describe the method of testing a Thomson recording wattmeter.

(b) Give a sketch of a lamp bank (incandescent lamps) for testing the above.

(c) Show by sketch the method of connecting the recording wattmeter into the circuit.

(d) Prove by this formula that the joint resistance of three wires in parallel is the reciprocal of the joint conductance:

$$R = \frac{R_1 R_2 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2}.$$

3. Describe the construction and operation, and how Nernst and Cooper-Hewitt lamps are started.

4. What three factors determine the size of a copper wire for transmitting current?

5. What would be your guide in selecting motors to operate several machines? Which would you advise, motors direct-connected to the machines, or motors connected to counter-shafting and belted to the machines? State your reasons for making your selection.

6. (a) What kind of terra cotta would you select for conduit (underground)? How would you lay the same, and what material would you use for the purpose?

(b) Make a sketch of a manhole for conduit and give general outline of the interior, showing conduits and cable supports.

(c) How would you splice a cable? Give step-by-step explanation of how you would start and finish up the splicing and the cable.

7. Give formula for measuring the insulation resistance by the use of a voltmeter, and describe its application to the insulation testing of the circuits of a public building.

8. Why has the coil of a voltmeter higher resistance than the coil of an ammeter, i.e., the ammeter coil being practically nothing compared with the voltmeter coil?

9. How would you measure the power in a two-phase (three-wire) alternating-current circuit with a Thomson recording wattmeter? Show by sketch your connections of the same in full.

10. What causes lagging currents in an alternating-current circuit?

THIRD DAY, SECOND PAPER

Subject: Same.

1. (a) Define reluctance, magneto motive force and magnetic flux.

(b) What is self-induction and what causes it?

2. Draw a curve of an alternating-current circuit showing the effective instantaneous values of the E.M.F. and currents. Give a *graphical* description of calculating the resultant current in the diagram (or curve) by the method of parallelogram of forces when lagging currents are visible.

3. Describe a synchronous motor and its operation. Under what conditions would you make your selection of a motor of this class in preference to an induction motor?

4. (a) Describe a direct-current low-tension arc lamp. Why is there always a resistance or a choking coil in series with the lamp?

(b) An arc lamp operates on a 110-volt circuit; it consumes 3.75 amperes of current when the voltage of the arc = 90 volts. Required, the resistance of the lamp, and the wattage consumed.

5. Make a sketch and describe fully the rotary converter and state which you would install, the above rotary or an induction motor coupled to a direct-current generator. Give your reasons for making your selection.

6. What are the advantages of the Y connection over the $\triangle$ connection, when used for long-distance transmission lines?

7. Make a diagrammatical sketch of two compound-wound generators, and describe step by step the method or the way you would connect them at the switchboard to operate them in parallel; explain fully.

8. What is a Clark cell? Describe it and state what precautions are necessary in using the same. (a) Describe the Plante and Faure types of storage accumulator, and the advantages of one type over the other. (b) How do you tell when storage cells are fully charged, and how do you tell when to stop discharging?

9. (a) How are multipolar motors changed so they will operate with two sets of brushes?

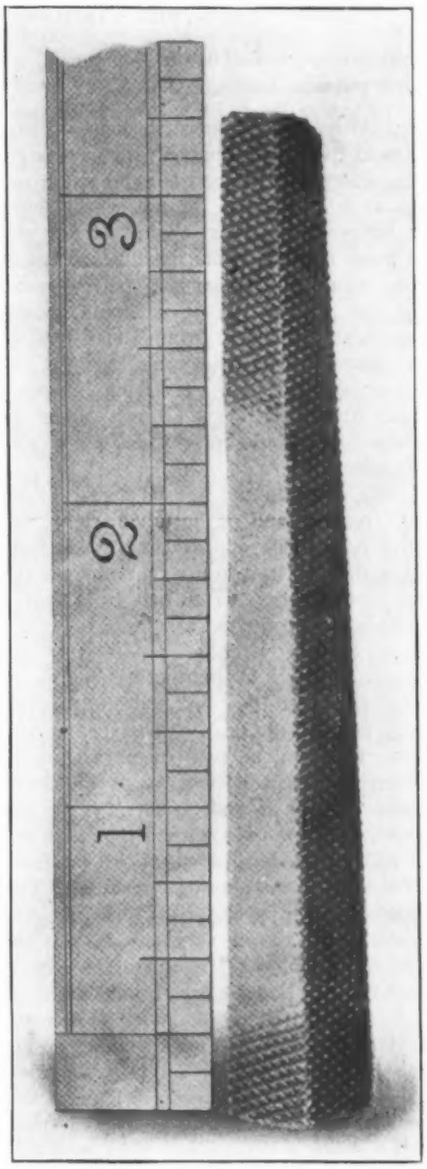
(b) Name four ways of raising the voltage of a dynamo.

10. Describe the Inter-pole variable-speed motor and show how the variations of speed are accomplished.

Erosive Action of a Steam Jet

Hon. Charles A. Parsons exhibited at a recent meeting of the Royal Institution of Great Britain the enlarged photograph (reproduced herewith) of a hardened-steel file, which had been exposed for 145 hours to the action of a jet of steam at 100 pounds pressure discharged into a condenser pressure of one inch absolute of mercury. The cutting action of the jet upon even this extremely hard material is plainly shown. In any of the turbines the velocity of impact of the jet on the blade is much below that of the jet in question, principally because the expansion is generally divided into a number of stages and even when it is not the relative motion between the blade and the jet is reduced by the receding motion of the blades.

Mr. Parsons said, "It has been shown by experiment that if drops of pure water arising from the condensation of expanding steam impinge on brass at a greater velocity than about 500 feet per second, there results a slow wearing away of the metal. It is very slow and would require about ten years to erode the surface to a depth of one thirty-



ENLARGED PHOTOGRAPH, SHOWING DESTRUCTIVE ACTION OF STEAM AT HIGH VELOCITIES

second of an inch. In the compound turbine the striking velocity is much below this figure."

Brown, Boveri & Co., of Baden, Switzerland, have received an order for a 15,000-kilowatt steam turbine for the Krupp works, in Germany. The overload capacity of this machine will be 18,000 kilowatts, involving the capacity to develop continuously 24,000 horse-power.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

"Loose Parts and Narrow Escapes"

I notice that Thomas Sheehan, on page 552 of the August number, suggests painting a stripe on the jam-nut and piston-rod, so as to tell when the nut works loose. I believe that on an engine of any size a loose rod will make itself heard before one would notice that the stripe was out of line. Then, too, if it should become loose, the attendant would hear it from a distance, while he could not see the stripe at a distance, nor from the other side of the engine. To rely upon the stripe, one would have to watch it continually.

The threaded rod is used on all classes of engines, and if installed right will give no trouble and is easily taken out. It is the only rod to use on ammonia and air compressors, as it can be adjusted without lining the pin brasses.

In locating a loose piston, you can assure yourself by putting the engine on dead center on the crank-end and "pounding" her. If the head has a taper fit and nut, there will be two distinct pounds: when the head goes toward the crank there will be a dull thud, due to the taper; when it goes toward the head end it will give a sharp crack as the flat faces of the head and nut come together. The head that is keyed on a taper fit will make itself known very quickly. Without exception, the piston that is riveted into the rod is the more troublesome.

I believe there is too much guesswork in Mr. Sheehan's method of taking up his pin brasses, especially on large engines. How often we see men drive home a key or wedge, run the engine awhile, and then set it down a little more; then stop and slack it off a bit. The sound of a pound is a very uncertain gage for closing brasses.

Put the engine on center, take dividers with sharp points and from a set point in the pin collar scratch two lines on the brass or rod. Have an assistant watch the valves and scratch a line with the brass against each side of the pin. Now draw down the key until the lines are together or nearly so. The distance between these lines is the exact difference in the diameter of the pin and the brass; there is no guesswork about it.

H. B. N.

Enid, Okla.

Reliability of Gas Engines

Although we hear reports from Germany of gas engines being regarded as economical and highly reliable, it still requires a great deal of argument to persuade the prospective purchaser in America that an internal-combustion engine is reliable enough for his needs. Of course it is generally conceded that internal-combustion engines are capable of being operated at less expense per brake horse-power than steam engines, even taking into consideration higher first cost, more expensive labor and more costly repairs. The one thing which is not conceded is reliability. The would-be purchaser has heard of the many failures and the innumerable excuses, and he becomes of opinion that it is easier to manufacture excuses than to build an engine which will not fail.

Manufacturers' guarantees are but poor consolation for losses due to shut-downs while repairs are being made on the engines, even though repairs are done by the manufacturers free of charge, according to contract.

Many steam engineers declare that there are no internal-combustion engines as reliable as steam engines. In my opinion, however, there are several makes of gas engines, any one of which, if well cared for and run under the conditions for which it was designed, would be just as satisfactory as a steam engine. But not only are they rarely operated under those conditions, but they seldom have experienced attendants. In nearly every case of failure there is some real excuse for the trouble apart from the design or construction of the engine. As a matter of fact, nearly every manufacturer employs a corps of experts to test every engine before it leaves the works.

The foregoing, then, appears to lay the blame entirely upon the purchaser, but this is not the case, as in reality it lies in the *method* of purchase and should be divided between purchaser and salesman, as a rule. For example, there may be very exacting conditions under which the engine would be required to run, yet the prospective customer is assured by the salesman that his engine will give complete satisfaction, and the salesman quotes his guarantee to give the purchaser confidence. Probably the salesman in question previously sold sewing machines or something equally remote from the gas-engine field and does not realize that there may be difficulty to meet the conditions of the case in hand.

After a short time devoted to the discussion of the fitness of the engine, and a long time to the adjustments of terms and discounts, the salesman triumphantly closes the bargain, promising everything, assuring the customer that the engine is perfection and delivering a written guarantee to clinch the sale. Then he wires a memorandum of the sale to the home office, followed by a letter in which he casually mentions the running conditions. Probably the men in the engineering department are aghast, but they are told to do what they can, without making radical changes in the engine. In the meantime the salesman is off to new conquests and the purchaser awaits the shipment with perfect confidence and a written guarantee. It is for the gods to decide what is to happen next. In some cases the engine may be of accommodating design, so that it can be used with the particular gas and in the particular position and climate required, besides being of fool-proof construction, so that the mistakes of inexperienced attendants are harmless. But in other cases—and somehow we always hear of the other cases—the engine goes wrong. The gas may be too rich or too poor, or impure, and there are stories of premature explosions, back-firing, broken cylinders and numerous other disasters.

Of course, all those who have read so far are ready to say that such results are probably avoidable, if the proper engine is selected for the conditions, or if the conditions are properly laid before the engineering department and a modification of the standard type is designed to meet the requirements. But how can this be accomplished? If manufacturers would replace drummers with engineers (who, by the way, usually have good business ability), and if the purchaser would hire an engineer to confer with these engineer-salesmen, instead of going himself or sending his commercial buyer, who is merely a manipulator of prices and terms, then I think there would be fewer stories of internal-combustion engine failures.

J. E. FULWEILER.

New York City.

In the Baku district of Russia oil motors are extensively used in prospecting wells and for oil-pumping plants. The fuel used is crude oil, as petroleum or benzine is too expensive. Air compressors are used also for pumping oil.

Information Wanted as to Blowing Down Boilers

From time to time we have seen articles referring to the correct manner of connecting a blow-off pipe to a boiler, but we have never yet read an expression from any POWER contributor as to how he knows whether a boiler has been blown down at regular intervals, or whether there is any device made for determining this.

We think this is a very important subject and would be very glad to get some information in this direction.

T. B. RICE & SONS COMPANY.

Philadelphia, Penn.

Hot Combustion Chambers in Oil Engines

It is strange that the idea of the hot combustion chamber in oil engines has not had wider recognition long before this. It is true that the vaporizer of the Hornsby-Akroyd engine is somewhat along this line, but it does not exactly conform to the practice as embodied in the engine referred to by H. Addison Johnston, in his letter on "The Ideal Internal-combustion Engine," on page 554 of the August number. Mr. Johnston does not compress an explosive mixture, nor does he, as is done in the Diesel engine, compress a charge of pure air to the ignition temperature of the fuel oil. He simply employs a small disk of some refractory alloy which stands prominently out from the piston-head in the combustion space, and is maintained hot by the explosion of the charge. [There is nothing new in the use of a hot plate for ignition—EDITORS.] The fuel is sprayed upon the disk after the air charge has been compressed and in this way ignition is certain and pre-ignition avoided. With this engine the first start can be quickly assured by the heating up of a small disk in the side of the cylinder. Heating this small, light disk is a much quicker process than heating a big vaporizer with a blow-lamp. In the Johnston engine, one of which I recently saw at work in Canada, the water-jacket extends only as far as as the piston travel, leaving the combustion end of the cylinder hot, so that all fuel is burned off and there is no clogging by decomposed oil.

The system of compressing an explosive charge which may fire prematurely has little or nothing to commend it. It is only to be regarded as a survival from early days, when men knew no better. In the gas engine it renders it dangerous to employ gas that is very rich in hydrogen, or compels great moderation in compression. Generally, it may be regarded as out-of-date for all large engines and it should soon become obsolete, for the danger of pre-ignition is always greater with large than with small engines. Mr. Johnston's oil engine is quite an innovation and is of great value and interest.

W. H. BOOTH.

New York City.

"Dubious Information as to Gas Producers and Engines"

I regret that my attention was not drawn to the editorial in the July number, page 489, referring to my paper on "Gas Engines and Producers for Central Stations," which was read before the National Electric Light Association in June, until it was too late to reply in the next number. Perhaps you will be good enough to grant me an opportunity to further explain:

I believe that in designing a gas engine the shaft is practically the first piece laid out, and is dimensioned for the horsepower at which the engine is expected to rate. With the shaft designed, the other dimensions of the engine follow and are closely dependent upon it. The size of the engine is now fixed, and has been fixed, practically, by the size of the most important and expensive single piece in the machine—the shaft.

Concerning the effect that the presence of marsh gas has on the operation of gas engines, my informant has further to say:

"While illuminating gas contains about 45 per cent. of hydrogen, it also contains nearly an equal amount of heavy hydrocarbons, which require a large amount of air for their combustion; the result of this is that a cubic foot of mixture as used in the engine contains only about 7 per cent. of hydrogen, and apparently engines having 60 to 90 pounds compression will operate very nicely on this percentage of hydrogen in the mixture, even where there is excessive temperature at some point in the combustion chamber. With the producer gas containing, say, 50 per cent. hydrogen, the percentage of hydrogen in the mixture is about 7 per cent., or nearly the same as with the lighting-gas mixture, but in the engine there have been some important changes made. The builder has now no doubt raised the compression of his machine to 125 or 150 pounds. The additional temperature of compression aided by the local heating, due to the hot points in the combustion chamber, combine to ignite the charge before it is desired, and the premature ignition results."

I will not burden your columns with reference to the other points that you spoke of, because they have not an important bearing upon the subject discussed.

ROBERT T. LOZIER.

New York City.

Advice Wanted Concerning a Centrifugal Pump

We have a 9x10-inch automatic engine which runs at 300 revolutions per minute, with 100 pounds steam pressure, developing, presumably, about 30 horse-power for driving a 6-inch vertical, centrifugal pump, directly attached to the casing of a 10-inch well, 375 feet deep. This pump is at the bottom of a 30-foot pit; it discharges through an inclosed pipe about 1500 gallons per minute, and carries on its suction side a vacuum of from 24 to 27 inches.

I wish to pipe the engine exhaust into this vacuum and would like to know whether the introduction of this amount of steam would be liable to cause a hammer of sufficient energy to endanger the pump, which is a very heavy cast-iron affair.

In case the pump should stop while the engine continued running, would there be danger that the momentum of water in the well-casing, or the weight of the water in the discharge pipe, would cause back-water to flood the engines? The pump discharges at the surface, level with the engine. Also, I would like to know whether the gain in steam economy would very much more than compensate for the loss of feed-water heat now taken from the exhaust.

G. W. WRIGHT.

Evangeline, La.

Peculiar Accident while Starting a Converter

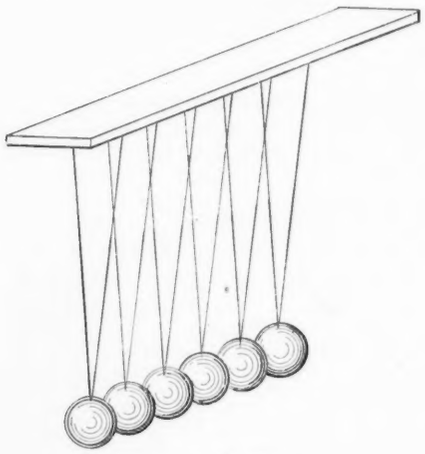
A peculiar accident happened recently as I was starting one of our 1000-kilowatt rotary converters. The machine is started by closing the positive circuit-breaker and working up to speed by means of a step-up switch. When the fourth step was reached, and the machine had only 30 more volts to pick up before it reached the full 240, the switch blew off and badly burned my hand and leg. At the same instant there was a great commotion among the bus-bars overhead, behind the switchboard, as though the current had jumped from one bar to the other of both sets, there being four bus-bars to each machine, on the direct-current side. It threw the other machine off, but caused no damage beyond blackening the commutators a little.

FRANK J. THOMPSON.

Minneapolis, Minn.

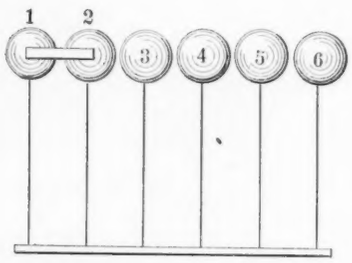
"Who Can Explain This Phenomenon?"

In the August number, page 556, the above query is propounded in regard to the phenomenon exhibited by a number



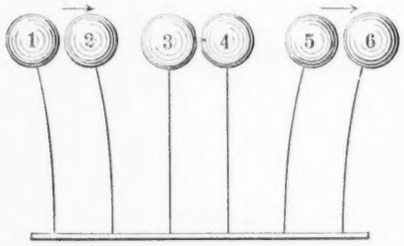
MR. CARTER'S FIG. 1

of balls supported in a line vertically on straight leaf springs. In order to properly answer "Inquirer," I submit three of his illustrations, which I have revised to suit the case, together with two sketches of my own.



"INQUIRER'S" FIG. 1. REVISED

In the first place, the number of balls which separate from the line at one end always will be equal to the number of balls which were drawn back and allowed to strike at the other end. Thus, when the four balls shown in "Inquirer's" Fig.



"INQUIRER'S" FIG. 4. REVISED

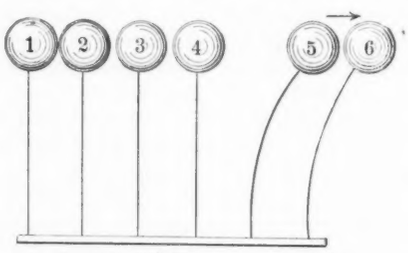
6 were made to strike the remaining stationary balls, had there been four or more of them instead of two, four balls would have swung to the right. This would have occurred because the balls which were drawn back and allowed to strike the remaining ones would not strike as a single ball of the same mass as the number so manipulated. They would strike in rapid succession, so rapid indeed that they would appear to strike a single blow. For instance, in "Inquirer's" Fig. 4, balls *1* and *2* do not strike simultaneously, but in rapid succession. The effect is as follows: The impulse of ball *2*, which strikes first, is transmitted successively to balls *3*, *4*, *5* and *6*, and ball *6*, receiving no counter impulse from the right side as do the intermediate ones, is swung off to the right. But the impulse of ball *1*, coming imme-

MR. CARTER'S FIG. 2

diately after that of ball *2*, produces a like effect upon ball *5*, which at that instant is the end ball at the right of the line, and therefore ball *5* is swung off to the right immediately following ball *6*. The time between these successive impulses is so minute that it is not perceptible to the eye, and so the balls at the right seem to move off together.

In a case where more of the balls are drawn back together and made to strike a remaining number which is less than the former, the action is modified somewhat. For instance, in Fig. 6 under favorable conditions balls *3* and *4* will be seen to separate from balls *1* and *2* and to swing to the right after *5* and *6* have done so. This of course is caused by the impulses given them by balls *1* and *2* after *3* and *4* have given up their momenta to *5* and *6*.

An experiment may be performed to prove the above. Suppose in "Inquirer's" Fig. 1 balls *1* and *2* are connected snugly by a link pivoted as shown. Now



"INQUIRER'S" FIG. 6. REVISED

if these two balls, so connected, be drawn back and allowed to strike the remaining ones, only one ball, namely, ball *6*, will be thrown off to the right, and it will be deflected with twice the impulse as would be the case if it received its impulse from a single ball at the left end of the line. Of course balls *1* and *2* must be so connected that there is no lost motion between them so that they will act the same as would a single ball of twice the mass of ball *1*.

Experiments illustrating the same principle may be made by suspending the balls by strings so that all of them can swing in only one plane as shown in my Fig. 1. Another method is shown in my Fig. 2, where balls or marbles are allowed to run in a groove which is inclined from both ends toward the center.

W. D. CARTER.

Austin, Nev.

In reply to "Inquirer," my explanation of the problem presented on page 556 of the August number is as follows: First, number the balls from left to right. When *1* is drawn back it possesses potential energy due to the tension of its spring, which is transformed into kinetic energy when the ball is released. When No. *1* strikes No. *2* its energy is transferred to No. *2*, but No. *2* being backed up by all the other balls, cannot move, except a very slight distance, and its energy is in turn transferred to No. *3* and so on through the line until No. *6* is reached. Being free to move, No. *6* moves out and is brought back by the spring, the same action taking place in reverse order, and No. *1* flies out. This cycle is repeated until the initial energy of the first ball is consumed by friction.

When two balls are drawn back and released the energy released is twice that in the case of one ball, assuming each of the balls to have the same mass. Their energy is transmitted through the line and two balls, No. *5* and No. *6*, fly off at the end. These two rebound and striking No. *4*, their energy is transmitted back to Nos. *1* and *2*, and these fly off.

When these balls are released the mass of the remaining balls (Nos. *4*, *5* and *6*) just equals that of those released and the energy is transferred direct; Nos. *1*, *2* and *3* are brought to a stop by the impact and the motion is taken up by Nos. *4*, *5* and *6*, which then rebound, are in turn stopped, and the energy is taken up by Nos. *1*, *2* and *3*. Thus they vibrate alternately in groups of three.

When four balls are drawn back and released, there are more momentum and energy than can be overcome by the remaining two balls, so they are not only driven off but the four are carried past the center of their swing. However, they have been checked by their impact against Nos. *5* and *6* and do not swing as far as they otherwise would. As Nos. *5* and *6* rebound they strike No. *4*, and although Nos. *1*, *2*, *3* and *4* are moving toward the left, the energy of Nos. *5* and *6* is transmitted through the line and Nos. *1* and *2* fly off, while Nos. *3*, *4*, *5* and *6* continue to swing toward the left, past the center. When Nos. *1* and *2* rebound, the action is repeated, Nos. *3* and *4* swinging back and forth and acting simply as a transmitting medium between Nos. *1* and *2* and *5* and *6*.

When Nos. *1*, *2*, *3*, *4* and *5* are drawn back and released, the action is similar to the preceding case. In this instance but one ball is affected (No. *6*). The

group of five strike No. 6 and being five times as heavy, No. 6 cannot stop them. It bounds away by the concussion and the group moves on toward the right to the end of its swing. As they start toward the left, No. 6 rebounds, and striking No. 5, its energy is transmitted through the line and No. 1 flies off, the remainder of the balls continuing to move toward the left to the end of their swing. When No. 1 rebounds, the action is repeated.

These experiments can be more easily observed if the balls are suspended by threads, say two feet long, in a straight line, the surfaces of the balls just touching.

The whole action is due to the elasticity of the balls and to the fact that they are of the same mass. If any one ball in the line were not elastic the experiment would not succeed.

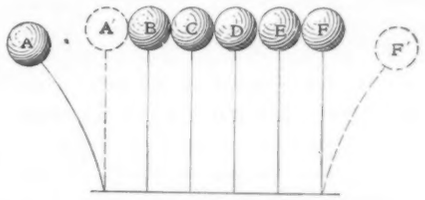
O. BURCH.

St. Paul, Minn.

In answer to "Inquirer's" question, "Who can explain this phenomenon?" I would say that the explanation is comparatively simple when the different forces and their effects are analyzed. Let us take the first instance, where the impact of the single ball *A* (see sketch) causes the last ball *F* to be thrown from the series, as shown by the dotted lines in the figure. In this case the ball *A*, in moving from the position *A* to the position *A'*, gathers a certain amount of kinetic energy which at the instant of contact is expended in compressing the surfaces of both *A* and *B* at the spot of contact; the reaction of this compression is passed along to the ball *C*, from the ball *C* to the ball *D*, and so on, until the wave of compression and reaction reaches the ball *F*, which having no mass on its opposite side to receive the impulse is itself projected forward with a kinetic energy almost equal to that of *A*, at the moment of contact, and would be exactly equal if operating under perfect conditions. The ball *F* will fly out until the flexion of the spring neutralizes the kinetic energy of the ball, when it will return, propelled by the spring, until it strikes the ball *E*, when a similar wave of compression and reaction will pass back through the series of balls and the ball *A* will fly out; this oscillatory action will be continued until all the initial energy is lost through the friction of the air and the imperfect elasticity of the balls.

In the second case both the balls *A* and *B* are drawn back and released. It is obvious however, that this is a similar condition to the first, the ball *B* acting exactly as the ball *A* did, the compression wave throwing the ball *F* off the end of the series. This is followed almost instantly by a second compression wave due to the momentum of the ball *A*, which throws the ball *E* from the series, thus making both balls, *E* and *F*, fly off together. These return and, reacting, cause the balls *A* and *B* to return almost to their original position. This oscillatory movement would possibly make it appear as though the line of balls was broken up into three divisions, as shown by "Inquirer."

The effect in the third instance when three balls, *A, B* and *C*, are drawn back, is similar to the second case, except that three waves of compression are formed



ILLUSTRATING MR. PEARCE'S EXPLANATION

and throw balls *D, E* and *F* from the series, and, *vice versa, A, B* and *C*. The fourth instance, however, is different. In this case the balls *A, B, C* and *D* are drawn back and allowed to return. The ball *D* throws off the ball *F*, the ball *C* throws off the ball *E*, leaving the balls *C* and *D* motionless for a fraction of time, until the wave of compression from the ball *B* comes along, which throws off the ball *D;* the ball *A* throws off the ball *C;* thus leaving the balls *A* and *B* motionless, while the balls *C, D, E* and *F* move outward, return, react and throw the balls *A, B, C* and *D* off. This oscillation and the leaving of the two balls at each end every time would possibly make it appear as though the series was broken into four and two, as shown by "Inquirer".

The fifth instance is the same as the first, reversed; that is, the balls *A, B, C, D* and *E* throw off the balls *F, E, D, C* and *B*, leaving *A*, and upon the return stroke the ball *F* is left as in the original instance. This also is different from what "Inquirer" shows, but I attribute this to the optical effect of the rapidly rebounding balls leaving one at the end at each oscillation, possibly making it appear at a distance that the end balls were both moving at the same time.

This problem reminds me of one I was asked some time ago: A train of ten coaches not coupled, but touching each other, is moving along a level track, when it collides with a single coach which is standing still. There is no locomotive attached. What will be the result of this; will the whole eleven coaches move forward at reduced velocity or will ten coaches proceed with undiminished velocity, leaving the last coach stationary on the track? Friction is not to be considered, and the buffer springs are supposed to be perfectly elastic.

GEO. P. PEARCE.

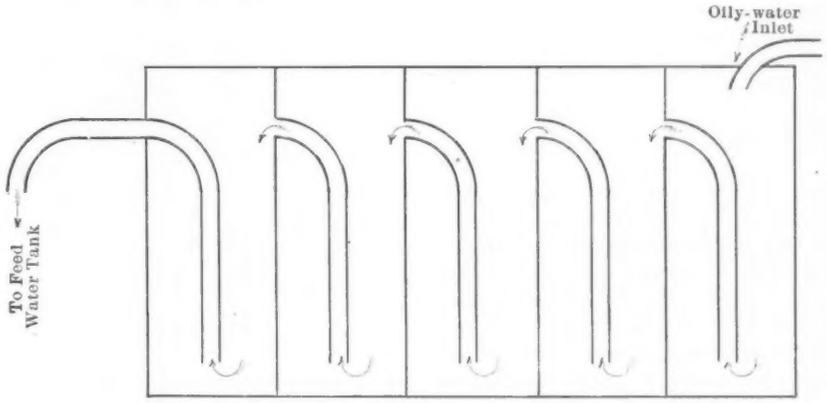
Williamsport, Penn.

"Cleaning Oily Exhaust"

On page 469 of the July number W. F. Burrow presents an arrangement for cleaning oily exhaust, and asks for a suggestion as to a better way to get the oil out.

Six years ago the method herewith illustrated was adopted, at my suggestion, at the plant where I am employed, and it has been in satisfactory operation ever since. The sketch shows a galvanized-iron water tank, divided into five watertight compartments connected to each other by bent pipes which extend to within 3 inches of the bottom and are flanged to the partitions about 6 inches from the top.

The oily water is delivered into the first compartment, and rising up the vertical pipe flows through the bend into the next compartment, and so on through each division, until finally it issues from the last compartment and is delivered to the feed-water tank. The oil, being lighter than the water, rises to the top in each compartment and can be skimmed off as occasion requires. We have since installed a tank divided into 10 compartments. Both tanks are handling something like 3000 gallons of water per day.



MR. STAFFORD'S METHOD OF CLEANING OILY EXHAUST

J. J. STAFFORD.

Birkenhead, Eng.

"Device for Adjusting Crank-pin Brasses while in Motion"

On page 553 of the August number, A. Charter asks if any of the operating fraternity would appreciate a device like that suggested in the above title. Although, during a long experience, I have never found the need of setting up a rod, as the saying is, without taking time to stop the engine, there are few engineers who have not seen the time when they felt willing to give a great deal to key back without stopping.

On one occasion a friend was taking a steamboat on its first spring trip through the upper lakes from Buffalo to Chicago. It was equipped with a steeple compound engine. Everything went well until he reached the narrows in the upper part of Lake Huron, when, as luck would have it, the crank-pin warmed up and he could not stop to key back. The connecting-rod was fitted with a strap bolted to the end and the brasses were adjusted by a wedge held in position with a lug and stud-nut. He conceived the idea of setting the key back without stopping the engine; so taking a small sledge and slowing down the engine, he placed himself in position to swing on the key as it came around, gaging his swing to the motion of the engine. In this way he was able to set the key back sufficiently to allow lubrication to occur, and with the aid of plenty of clear, cold, lake water, the crank-pin resumed its normal temperature. It is not known how much the key or adjusting screw was strained, however.

It seems to me, in view of this experience, that a convenient apparatus to enable an engineer to key back would be most welcome.

ROBERT MATHESON.

Kingsbridge, N. Y.

Regarding A. Charter's suggestion on page 553 of the August number, I would reply that my experience has not included many kinds of engines, but in our plant of six engines of three different makes and four different styles I have not felt the need of such a device. It seems to me that too many of us try to cure the jars and noises by making adjustments at the pins and bearings; as an engineer develops he works away from the crank end toward the cylinder end of the engine. My guide in this matter is Mr. Porter's reminiscence of once inviting some gentlemen to come and see him back the key of a quiet-running engine so that the crank-pin had 1/32 of an inch play, and, starting the engine, it ran as quietly as before.

Of course, we who run engines cannot do this, but it indicates what we should strive for, and when we get one fixed so the crank brasses do not have to be adjusted more than once in two months, and then not because they pound, but simply because they are loose, we will not mind having to shut down in order to do it.

LLED.

New York City.

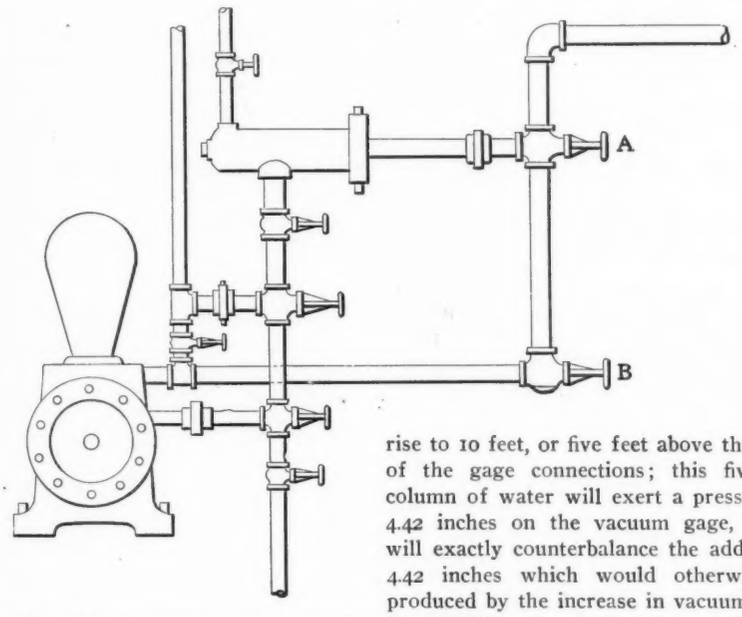
I do not believe A. Charter's suggestion would be used to any great extent. There has been patented a device for that purpose. There are very few engines which cannot be shut down long enough to take up the brasses. Such devices are more or less complicated and liable to get out of order, and will not pay for themselves.

H. B. N.

Enid, Okla.

"Piping a Steam Pump and an Injector"

On page 559 of the August number "Beginner" shows a very neat and practical way of arranging piping and valves for feeding a boiler. However, I wish to suggest that he could make a slight improvement by discarding the inverted gate valve and substituting the cross-valve as shown at *A* in the accompanying sketch, also by using an angle valve at *B*, in place of the gate valve which he recommends. Gate valves and every other nuisance should be avoided wherever it is possible to do so.



MR. WAKEMAN'S SUGGESTION FOR LOCATING VALVES

W. H. WAKEMAN.

New Haven, Conn.

"Effect of Location on Indication by Vacuum Gages"

Referring to R. B. Hendron's query on page 552 of the August number, I think the gages will each indicate the vacuum equivalent of the column of water beneath the line where it is connected to the suction pipe, and I think I can prove why this will be so. Let us start with the suction pipe empty, as when erected. The pump is started and a vacuum commences to form, causing the water to rise. Since the vacuum is the same throughout, all the gages will register alike and this will continue until the rising water passes the connection of the first gage. The vacuum still continues to increase and the water to rise, but no further effect can be produced on the first gage because the increase in vacuum is, and must be, exactly balanced by the hydrostatic head of water above the gage connection.

Suppose the first gage is connected exactly five feet above the water level, then as soon as the water reaches that level the gage will show 4.42 inches of vacuum; now, suppose the vacuum is increased to 8.84 inches, this will cause the water to rise to 10 feet, or five feet above the level of the gage connections; this five-foot column of water will exert a pressure of 4.42 inches on the vacuum gage, which will exactly counterbalance the additional 4.42 inches which would otherwise be produced by the increase in vacuum. The result will be the same at any other hight above the gage connection, and the same will be true for the second, third and fourth gages—they will all record the vacuum equivalent of the column of water beneath the level of the connections, irrespective of the hight of the water above.

The gages could all be made to register alike during the operation of the pump, if the gage-connection pipes were to be filled with water; for then they would be supporting a column of water equal to the hight of the gage above the water level.

GEORGE P. PEARCE.

Williamsport, Penn.

"Etiquette in the Engine Room"

In answer to W. H. (page 479 of the July number), who asks if it would be courteous or right for him to use his own indicator, without asking his chief's consent, I would say that if he will apply the Golden Rule to his problem, he will find his answer.

From an experience of fourteen years as chief of a 2000-horse-power plant, I am sure that any man in such a position would talk to a subordinate who did such a thing in vigorous English that could not be misunderstood. On the other hand, if a man were to ask permission to indicate the engine, the writer would not only grant it, but would also give him all the information he asked for.

My contention has always been that any chief who refuses to give all the information his subordinates can assimilate is very short-sighted, as the more they know the more efficient they become, and the more capable of exercising good judgment in emergencies, for in plants with several engine rooms scattered over a more or less wide area a chief must depend on his "runner" for the first steps.

Any man in the position of chief engineer, with all its responsibilities, is not only entitled to know all that is going on in his plant, but he must insist on knowing every contemplated move, for his own protection; not that the particular act of indicating the engine would do harm, but doing of this might lead to the doing of something else, until finally the "runner" might do something which, while it might seem perfectly harmless as far as his engine room is concerned, would make trouble elsewhere, and this would appear at once to the chief, who would have in his mind the efficient working of the *whole* plant.

HENRY E. FISHER.

Boston, Mass.

Removing the Seats from Blow-off Valves

Recently we were confronted with quite a problem while repairing leaky blow-off valves. It seemed that all the valves began leaking at the same time, and when one considers the amount of steam that can escape from sixteen 2½-inch leaky valves, one can readily see that the consumption of coal per kilowatt-hour was on the rise pretty fast.

In this pattern of valve it was an easy matter to re-babbitt and face off the valve disk, but removing the valve seat after it had become corroded in the valve chamber was very different. Originally the seat had been threaded in, but the threads becoming worn, they were cut out, the valve bodies bored out and new seats turned to an easy driving fit. Fig. 1 gives an idea of how the valve looks.

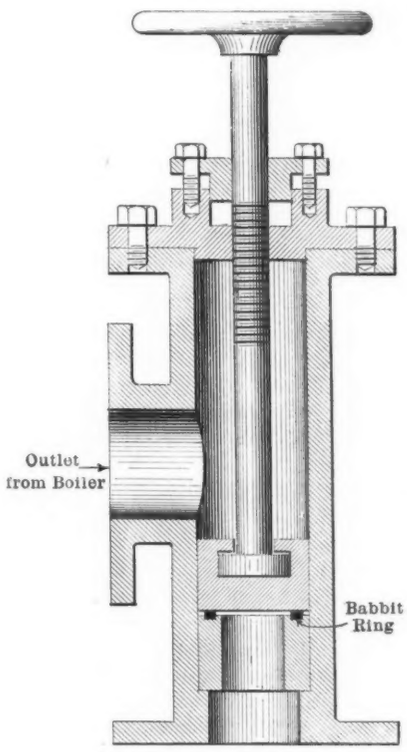


FIG. 1

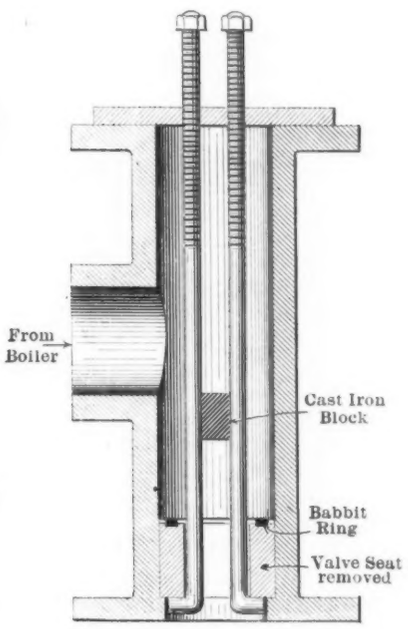


FIG. 2

We made several ineffectual attempts to remove the seats with hooks. Next, the heads were cut from two ⅝x12-inch bolts and the ends were heated and turned L-shape, the offset being made the same length as the thickness of the valve seat, which was in the form of a ring. These bolts were placed in the valve chamber and made to hook under the valve, as shown in Fig. 2. A ½-inch plate was then cut, drilled and placed over the bolts as shown. The L-shaped ends slipped off at first when drawn up very tight, but by placing a cast-iron block between the bolts this trouble was overcome. In this manner all the seats were removed.

J. BURNS.

Columbus, O.

"Effect of Compression on Cut-off"

I like what Mr. Mason says about compression on page 559 of the August number, for it agrees with my experience. When originally started, our Corliss engine ran fairly quietly, but its operation was improved by doing away with all lead on the steam valves. Looking for further improvement, I noticed that the short exhaust valve-rods could be turned considerably without causing a pound, but when turned for less compression the speed would increase noticeably before the governor acted.

This led to adjusting the exhaust valves so as to just keep the centers quiet, and now a slight turn of the rod will cause a pound. I think it takes less steam this way and keeping on the verge of the noisy point, any little derangement of the valves will be noticed more quickly than when there is such a margin on the side of quietness from having more compression.

I have no trouble with the pins and let them run while very loose, giving the crank-pin one drop of oil to each thirty revolutions.

LLED.

New York City.

Will Somebody Oblige?

I would like to ask if the "Examiners' Questions to Engineers," published on page 553 of the August number, were questions actually asked by examiners. I fail to see the application of some of them for all cases. Take, for instance, the first examiner's Questions 6 and 7, the second's Questions 4, 5 and 6, and the third's Questions 7 and 8.

Can any POWER reader answer these seven questions so the answers would be applicable for all conditions?

BEGINNER.

Exeter, N. H.

[The first examiner's Question 7 should read, "the *condenser* being direct-connected, instead of the "conductor."—Editors.]

Changes of a Quarter of a Century

Memory carries me back to the engine rooms of twenty-five years ago, with their Corliss, their high-speed automatic and their slide-valve engines—all small when compared to the engines of today, and mostly driven by belts, a few by ropes, but none direct-connected. I recall vividly the daily routine in a certain engine room of twenty-two years ago. A few minutes before 7 o'clock the engine was started; at 7 the whistle was blown, the oil cups looked after once more, the lubrication was slowed down a drop or two, followed by a touch here and a wipe there with a wad of waste; then a trip into the boiler room and back; next, just a few minutes with the broom on the floor, then a quiet smoke—everything running smoothly, everybody contented, no worry, no headaches. At noon came the shut-down for dinner, or just long enough to oil up, and at 6 the shut-down for the day; or, if there were day and night shifts we stopped for a little talk with the relief and then—home to supper.

But, nowadays, what a change!

Everything is hustle and bustle, large and grand, with everyone on the jump, whether chief, assistant or oiler, fireman or coal-passer. Here the receiver pressure is too high, again too low; the air-pump is losing its vacuum; dash-pots are not working right; or perhaps the steel plate on a governor hook is broken, compelling the shutting down of a 5000-horse-power unit just long enough to replace the plate. The boiler pressure has to be run up from 125 to 145 or 150 pounds, so that the other units may carry the extra load. Then, hurry to the top of the disabled engine, replace the plate, inspect the others and get started as soon as possible! True, all this can be done in 10 or 15 minutes; yes, I have seen it done in 9 minutes, and the load equalized in from 12 to 15 minutes.

Did the engineer of the "good old days" have the worry, the headache, the gray hairs that the engineer of today has? No. Is it worth while? Is the engineer benefited? Is his family better off? Yes. Employer and employee have kept abreast. The mechanical engineer, the inventor, the manufacturer of complicated engines have found in the painstaking, reading engineer a coöperator who has made the modern power plant a possibility. Correspondence schools, night schools and engineers' associations have all had a tendency to raise the obscure engineer to a higher plane. In many instances the man himself, by a regular course of home study and by keeping his eyes and ears wide open, has improved his lot in life.

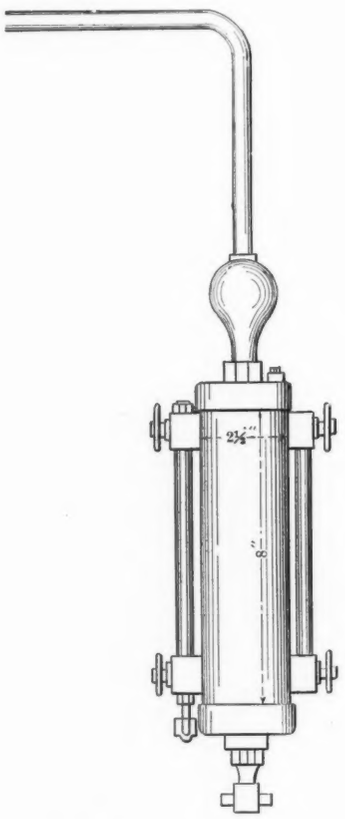
How much easier is it for an engineer today to gain the education he seeks than it was twenty or twenty-five years ago? As a POWER correspondent stated a short time ago, valuable information is readily obtainable by subscribing for a technical or trade journal, while in catalogs that can be had for the asking and a postage stamp, the desired information frequently can be procured. It has been my pleasure to see engineers of small, obscure plants gradually raise thmselves to the charge of some of the largest power stations through their own efforts.

REX.

St. Paul, Minn.

An Improvised Lubricator

I recently heard of a case where the sight-feed lubricator of a boiler feed-pump was too small for the pump and consequently had to be filled quite often. The



AN IMPROVISED LUBRICATOR

engineer soon became tired of this and mastered the difficulty in the following manner: He procured a piece of 2½-inch iron pipe about eight inches long and, having threaded it, capped both ends. He then drilled and tapped a hole in the top for the condenser and one in the bottom for the drain-cock, and after drilling the necessary holes for the other fittings, he stripped the old lubricator and attached the fittings to his home-made cup, which is illustrated herewith. He found that it worked remarkably well, and saved him a whole lot of work.

JOHN M. SWARTZELL.

Chevy Chase, Md.

"How Can He Increase the Draft?"

As I understand Mr. Burdekin's appeal in the June number, page 399, his chimney is too small for the work it has to do. When any piece of apparatus has more work than it can do well, the simplest remedy is to remove part of the load. If Mr. Burdekin would connect the intake side of his blower to the flue, as near to the boiler as possible, and run the delivery up far enough to get the smoke out of the way, he would have better draft, certainly better than if he puts cold air into a chimney which already has more gases than it can properly handle. Of course, this can only be done if his blower can handle hot gases. Or, he might blow the hot gases back into the chimney, running the pipe into the stack and turning it up with a piece of pipe long enough above the elbow to prevent eddies. If there is another hole in the chimney, besides the one where the flue enters, it would be better to use it to avoid filling up the flue.

Mr. Burdekin's drawing shows what I take to be a damper, and it is closed. If he would open the damper, it might help his draft some too.

HARRY D. EVERETT.

Jamestown, N. Y.

"How Does Superheated Steam Affect Fittings?"

Referring to the above question which was asked by E. L. Broome, on page 556 of the August number, I would say that I have heard considerable discussion and seen a great many reports on this subject, and if Mr. Broome were to look on the inside of a cast-iron fitting which had been affected by superheated steam, I do not think that he would see any indications of the "high temperature bug" he speaks of. My understanding of this matter is that steam at high temperature affects the ferric structure of the iron; in other words, destroys its composition and strength. This action, however, would probably not be noticeable to the eye, but could readily be told by examining a fresh break or making a tensile-strength test. The experience that engineers have had, notably in Germany, has been that open-hearth steel castings are the only fittings which are unquestionably reliable for high-temperature steam work.

C. W. E. CLARKE.

New York City.

In Chicago recently a blind man, who runs a coffee shop in the front part of his house, was appointed examining engineer at $2000 per annum.

Mr. Brand's Transformer Connections

I have read the problem presented by H. B. Brand, on page 559 of the August number, and submit herewith my solution, shown by the accompanying sketch.

The primaries of the transformers should both be connected to the same phase, as shown in Fig. 1. This arrangement will give full secondary voltage across the secondary mains, and the operation will be as it should be.

If the connections were made as in Fig. 2, a local current will be exchanged between the secondaries, due to the fact that the two currents are out of phase. With one current lagging ninety degrees behind the other in the primary mains, it is evident that when the current in one secondary is at its maximum value, the current in the other secondary will be at zero; consequently, there will be an interchange of current between the two, which current would probably be quite large, due to the low resistance of the secondary windings.

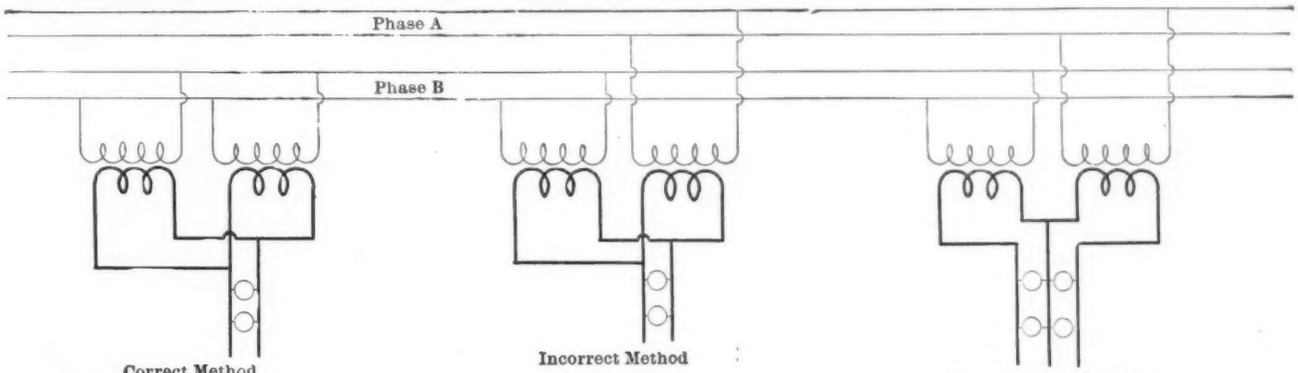


FIG. 1 FIG. 2 FIG. 3

It is, however, possible to connect to both primary mains to form a kind of three-wire arrangement, as shown in Fig. 3, but this arrangement is not satisfactory. The voltage across the two outside secondary wires is not equal to twice the voltage across one secondary, but is 1.414 × voltage of each secondary.

The better plan is to bank the transformers on one phase and equalize the load on the two phases by dividing the load between the two at various points on the line.

C. L. GREER.

Handley, Tex.

"A 100-Horse-power Steam Plant"

In Mr. Hobart's article in the July number, on page 422, mention is made of a 5x4-inch hand-hole in the back head of the boiler. I think that this is not good practice, as it is almost impossible to keep such a hand-hole packed so that it will not leak. Furthermore, of what benefit or use is a hand-hole in the back head? If it should leak, as they generally do, it is almost impossible to get at it to tighten it, particularly while fire is under the boiler and the steam is up. As a matter of fact, in practice usually a patch is put on in the course of time, in place of the hand-hole plate, or else the metal in the head becomes thin, or is so corroded that it is dangerous.

X.

St. Joseph, Mo.

"Effect of One or Two Throttles on a Duplex Steam Pump"

In reply to Frank J. Wood's letter on page 475, of the July number, I would state that even a duplex pump can be made less efficient, and I think that would be the result of a separate throttle for each cylinder. The piston is cushioned and slows up before the steam valve closes. With separate throttles, steam would keep flowing into the cylinder until it reached the boiler pressure or the steam valve closed. With one throttle, the pressure is kept down by the other piston, which is moving at full speed. The result would be that with two throttles the pump would take a cylinder full of steam at nearly boiler pressure at each stroke, while with one throttle it takes a cylinder full of steam at pressure enough to run the pump at the required speed.

HARRY D. EVERETT.

Jamestown, N. Y.

Packing Valve-spindles under Difficulties

In our plant all the valves on the main steam lines and the feed lines are gate valves, and I have my own troubles in packing the spindles. In fact, it entails shutting down part of the plant. The maker of the valves claims that they can be packed when wide open, but I am sure that he cannot do it after they have been in use a few years, and make a good job of it.

Why is it that when the steam is shut off one side of a gate valve the pressure still gets to the stem packing? Would a ¼-inch vent in the bonnet relieve it enough to allow me to pack the gland with pressure on one side only?

We carry 150 pounds steam pressure and have 50 gate valves, from 14-inch down to 2-inch, on the steam, water and exhaust lines, and these valves are not very conveniently placed for shutting off steam from them without crippling parts of the plant.

R. W. J.

Chicago, Ill.

Why Does the Converter Fail to Pick Up Load?

We have two small rotary converters connected in parallel on the bus-bars, and while the negative machine will at once seize 600 or 800 amperes, when in phase with the generators, the positive machine will run for from five to fifteen minutes before any signs of its taking load are indicated by either ammeter.

After a while it will pick up a small load, but it lags from 200 to 300 amperes behind the other machine all the time. Altogether there are four 35-cycle 110-volt converters connected with the same set of alternating- and direct-current bus-bars. Three of them pick up about the same, while the fourth lags, as stated. I have examined all the leads and other connections, but found nothing wrong.

Can any POWER reader explain the cause and suggest a remedy?

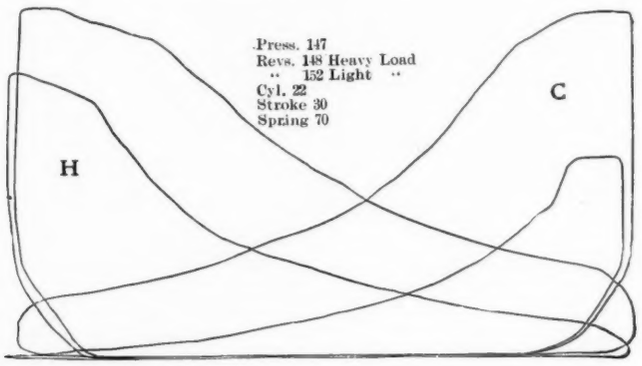
They are compound-wound machines, but on account of batteries being operated with them, it was necessary to cut the series winding in with the shunt. They supply current to different sides of the neutral of the Edison three-wire system, on the direct-current side. Until last winter they all worked O. K.

FRANK J. THOMPSON.

Minneapolis, Minn.

What Is the Matter with These Diagrams?

I submit herewith indicator diagrams from a new engine of the 4-valve, Corliss, automatic, non-releasing type, which has been running only about three months. The engine is equipped with an inertia governor, such as is furnished with Hamilton-Corliss engines. I lengthened the indicator cord to take the light-load diagram, so its action would show more plainly. The crank-end cut-off occurs a little earlier than the head-end, but why is there such a difference between the initial pressures, and why do not the steam lines keep up to pressure better?



WHAT IS THE MATTER WITH THE DIAGRAMS?

ASSISTANT ENGINEER.

Bellingham, Wash.

Anent Blueprints

We had received orders to put up the shafting for a new grinder that was booked to arrive soon. Two blueprints of the necessary shafting lay-out, a plan and an end elevation, were handed to us and we were politely invited to get a "hustle" on, as the "old man" was anxious to see the machine coin money. (No, it was not a "coiner"—it was a "grinder.")

"Please, Mr. H———," said the millwright, "the figures on these plans are very few and far between."

"Are the plans scaled?"

"Yes; but 50 inches in one place and 56 inches in another look alike to a steel scale, and the whole thing is drawn to 1½ inches to the foot."

"What of it? All you've got to do is remember that every 1-16 inch on your plans equals ½ inch. That is close enough. This job is in a hurry; so pitch right in and let us see what you can do."

"Thanks. That tip about 1/16 inch = ½ inch is O. K. But, just a minute. I happen to know that the hangers shown on these plans are non-adjustable and generally have only ¾-inch cored holes for their ⅝-inch supporting bolts. How about them?"

"Well, you'd better not bore for the hangers; leave them out; just put up the stringers."

"Um-m," and he went away as if half in doubt as to the propriety of leaving me alone.

About an hour later I went up to the floor where the new machine was to be located to take a look at the progress that was being made.

There, over a pair of carefully spread and ballasted blueprints, was the millwright making faces at himself and the prints, alternately.

"What's the trouble now?" I asked.

"Say, what offset do you want to give your machine?"

"What *what?*"

"How much do you want the belt from the countershaft to slant to the machine? Dropping a plumb-line from the center of one of the ends of your countershaft and doing the same from the cone-shaft of the grinder, how much do you want between?" he carefully explained.

"Look at your blueprints, they ought to tell you at least that much."

"Please, Mr. H., those are not my blueprints, or maybe I'd understand them. This end elevation, which should show the offset, despite all evidence to the contrary, is *not* drawn out fully. Though the belt lines, which according to scale and common sense should be broken between the counter and machine, are fully drawn out, you can readily see it is not a 'full' drawing; of figures there are none."

"Figure it out, anyway, as if the drawing were right. Measure the distance of the belt centers as regards the hight and the offset, and determine what amount of offset the machine should have for each foot of hight. See where that will land us on this ceiling."

He figured patiently for a while. Then he seemed to check up his figures, as if to make sure of their accuracy. Next he looked carefully out of the window, and then he turned to me.

"How long ago is it since the Western Union put its wires underground in this vicinity?" he asked.

"About five years ago," I answered. "But what, in Heaven's name, has that got to do with our countershafting?"

"O, nothing, only if the change had not been made, you could order up post-hangers and stick your counters on the Western Union poles."

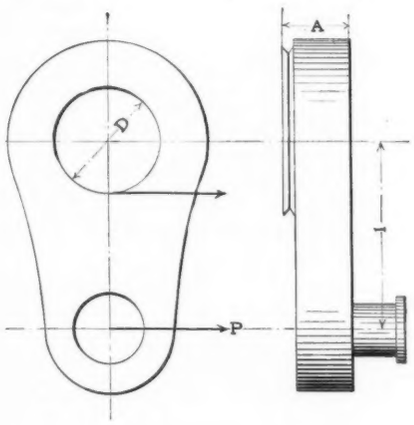
CHARLES HERRMAN.

New York City.

Proportions of Engine Cranks

The appropriate width and thickness of the crank of an engine afford a very interesting study. We are making them in steel, of the proportions shown in the accompanying table. Many engine builders in America are making these cranks from castings.

It would be interesting to know the minimum thickness at *A* which has been employed up to this time, for pressure conditions and diameters as given herewith.



Cylinder Diam.	Pressure P/Kg.	Radius of Crank-pin Circle l	R.P.M.	D	A	D/A
400	10000	400	100	165	110	1.5
450	12700	450	95	200	135	1.5
500	15700	500	90	210	140	1.5
600	22600	600	85	280	155	1.8
760	36300	750	80	380	230	1.65

ENGINE-CRANK PROPORTIONS

Inglin & Spencer used much smaller dimensions without any trouble.

H. BOLLINCKX.

Brussels, Belgium.

What Is the Matter with the Vacuum?

The diagram herewith gives some idea of the lay-out of the water station where I am employed. The installation is known as the "vacuum system." It worked all right for a number of years, or as long as

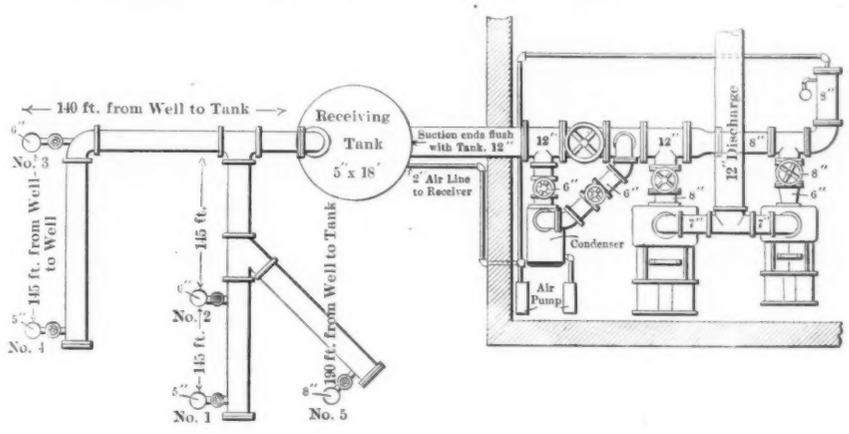
the demand for water was comparatively slight, but when more water was wanted, the trouble commenced. The vacuum would break every once in a while, so that I could not run the large pump with a condenser, as every time it broke the condenser got very hot on account of the air getting in ahead. Then in a short time the small pump began to give trouble, so I had to cut out the condenser and run under high pressure. This worked for a time, when the trouble re-commenced, and I had to run very slowly to prevent the vacuum breaking. If the air pump does not get the best of the air, I have to stop and get the air out of it or the pump will not work.

Thinking that the trouble was due to a shortage of water, the owners sunk an 8-inch well with a flow of 200¼ gallons per minute, but this does not help in the least. With the vacuum gage on the suction chamber I have gone around to each well and tested the connections, only to find the piping of the wells to be all right. When all five wells are on and the air and water pumps are running, I can get a vacuum of five inches at the suction chamber, but beyond that the air pump will commence to give trouble. At the same time the water will flow from the top of wells 1, 4 and 5, which are the farthest away. The superintendent believes that by putting in a larger air pump, things will be O. K.; but I think that that will only give relief for a short time, if at all, because when pumping on a vacuum, it is only possible to draw from the nearest wells, which are in the line of least resistance. If the nearest wells were large enough to supply the pumps with water, or if the other wells had head enough to flow to the pump and force the air ahead, there would be no trouble; but to form a vacuum on 290 feet of 8-inch pipe, and then draw the water from the wells, gives the air too great a chance to pocket and cut the water off. I claim that the proper way is to dig an open well 30 feet deep for the suction chamber and siphon the water into it, thus doing away with the air pump entirely.

Can any POWER reader throw light on the subject?

C. L. TROWBRIDGE.

Chatham, N. J.



LAY-OUT OF MR. TROWBRIDGE'S WATER STATION

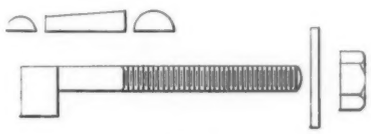


FIG. 1

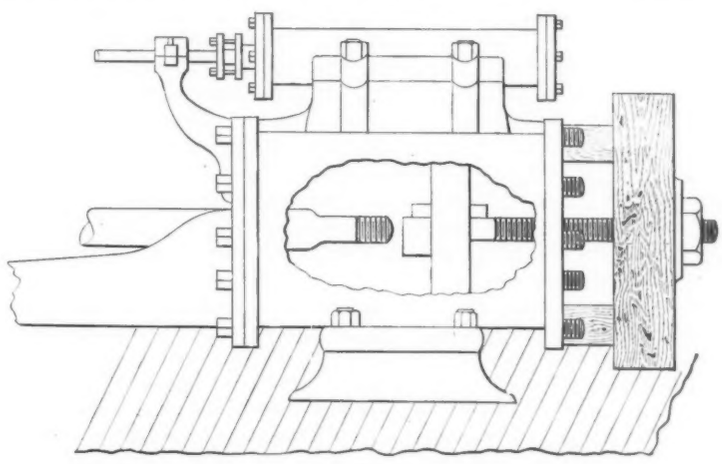


FIG. 2

Trouble Caused by Broken Packing Ring

A single-acting feed-pump went back on me very suddenly, and no amount of boring, jacking or other experiments would start it one way or the other. I took off the steam cylinder-head and piston-rod nut and forced the rod out of the piston. Then I had a bolt made like that in Fig. 1, with a one-sided head, and inserted it with a half-round wedge to secure it, as shown in Fig. 2. That cured the trouble. It seems that the packing rings had worn thin and one of them had broken and become wedged between the piston and the wall of the cylinder.

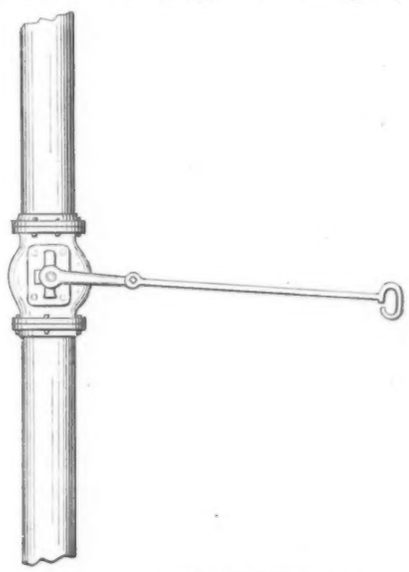
BEGINNER.

Exeter, N. H.

"Weighting a Back-pressure Valve"

On page 551 of the August number W. H. Wakeman appears to have erratic ideas as to the situation of my valves and their operation which he can correct by referring to my article in the June number.

Referring to the valves in my heating mains (those which I am supposed to "climb up a ladder to open and close"), the accompanying illustration shows how I had the valve wheel removed and replaced by a lever, from the end of which extends an iron rod, with a handle as shown. When the rod is in the position shown, it is 6½ feet from the floor. This obviates the dangling, dust-collecting rope arrangement. I have had charge of a rope-drive system and highly favor it for some purposes, but I do not care to use one to operate my wheels.



MR. SHERIDAN'S ARRANGEMENT

JAMES G. SHERIDAN.

Brooklyn, N. Y.

POWER

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Civil Service Examination for Chief Engineer

The Civil Service Commission reconsidered its ruling that nobody but a graduate of a recognized institute of technology could take the examination for chief engineer of Government buildings, and an examination open to all comers has been held. One of the candidates sends us, from memory, the list of questions which were asked. It is evident that the list, which will be found on page 698, is not entirely correct; but it will serve to indicate the character of the examination.

A man who can be shut up in a room, away from all sources of reference and information, and pass that examination, has no time to spend running the mechanical end of a post office at $1800 a year.

The "Lusitania"

Upon her maiden voyage the new Cunard Line turbine steamer "Lusitania" failed to break the record only by the establishment of a new record by the "Deutschland" of the North German Lloyd. She represents all that is latest in marine design—whether it is the best remains to be seen—and her appearance is a fitting climax to the century of development inaugurated by the success of the "Clermont." She is the highest-powered vessel afloat, having Parsons turbines rated at seventy thousand horsepower, greater than the normal capacity of the first great power stations erected in New York, and which were thought so enormous a few years ago. Details of the power equipment are as yet unavailable, but a fair idea of what the runner of one of her turbines looks like may probably be gleaned from the photograph reproduced on page 723. Definite information of the comparative efficiency of the "Caronia" and the "Carmania," the liners which were fitted one with turbines and the other with reciprocating engines, has not been made public, from which it may be inferred that the turbine performance has not been such as to warrant shouting; but at least the turbine steamer has made its trips regularly and has been popular. It would be difficult to put this amount of power into a ship with reciprocating engines, and coal consumption is not the only factor to be considered in a vessel of this kind.

It is announced that an order has been placed with Harlan & Wolff for a large steamer, to run between Liverpool and Canada, in which two sets of quadruple expansion reciprocating engines will be used in connection with a low-pressure turbine, each having its shaft and propeller. This is the system urged by Professor Rateau, and it certainly promises an increased steam efficiency.

A Complete-expansion Gas Engine

The typical internal-combustion engine of today discharges its exhaust gases at 20 to 40 pounds above atmospheric pressure, and the two-stroke-cycle engine continues to take its charge in brief gulps and simultaneously to discharge its burned gases in almost equally brief snorts.

An English engineer has risen to the occasion and proposed a construction and method of operation which appear to provide a practical elimination of the drawbacks mentioned in the preceding paragraph. In a paper read recently before the Institution of Civil Engineers, of Great Britain, James T. Milton proposed an engine using the two-stroke cycle, but in order to enhance the efficiency and increase the output per piston stroke, he suggested that *all* compression be done in air and gas compressors; that the engine be built with the smallest possible mechanical clearance; that the compressed air and gas be admitted separately during a small part of the piston stroke, the supply then cut off, and, simultaneously, the mixture in the cylinder ignited.

The proposition is a most interesting one, even from the standpoint of the land gas engineer. The compression pressure could be made anything one chooses to design the engine for without liability to pre-ignition; expansion could be carried down to fifteen or sixteen pounds absolute by adjusting the cut-off to that end; one design of engine could take any kind of fuel with no change in design beyond adding a sprayer and using a small pump instead of a compressor when oil is the fuel; a full stroke of the piston would be available for expelling the burned gases, although using the two-stroke cycle; the expulsion of burned gases would be almost complete, because of the small clearance, so that the fresh charge would not be greatly contaminated.

Of course there are many details to be worked out. It is essential, for example, to mention the most obvious points, that the air and gas must not be allowed to mix outside the cylinder; that ignition should actually occur at the exact moment when the incoming fluid is shut off, and that expansion should not be carried appreciably below atmospheric pressure even at the lightest loads. But in the light of gas-engine history thus far made there seems to be no grave difficulty in the way of applying Mr. Milton's suggestion to both land and marine service, and there are certainly many advantages embodied in the plan. Dugald Clerk made tentative experiments along the same line many years ago, but he unfortunately compressed the mixture of air and gas in a single pump, with results that could easily be predicted nowadays but were not so obvious then.

The Value and Purchase of Coal

A step in the right direction has been taken by the United States Geological Survey in preparing specifications under which all steam coal for the various branches of the Government will be purchased in future. The general plan of these specifications is to make a certain percentage of combustible the basis of the purchase price; for lower percentages there is a scale of penalties and for higher a scale of premiums. This should certainly give more rational valuation than the present unscientific scale of prices based chiefly on transportation charges and the mine-owners' avarice. Fruits, vegetables, lumber and other natural products vary in price approximately according to quality; why should coal be an exception?

Of course the adoption of the specifications will probably blight the engineering careers of the "bo's'n's mates," carpenters and laborers who have enjoyed the distinction of being selected to inspect and pass upon coal purchased at some of the navy yards and smaller Government stations; the Geological Survey inconsiderately proposes to have all tests and inspections made by members of its own staff. Worse yet, if the mania should spread to State governments and municipalities it is likely to curtail the "honest graft" of many an embryo statesman. The honorable undertaker, for example, who has been buying all the coal for the city of Boston, would be grievously handicapped in his activities and put to the trouble of learning what combustibles and bills of lading are, both of which subjects he now cheerfully considers wholly academic. Questioned, in a recent investigation of alleged graft in Boston's purchasing department, as to what precautions he took to secure good coal for the city, this remarkable official is reported to have said that he "asked Daniel Doherty and a Mr. Anderson about prices of bituminous coal," but no testimony was offered as to the qualifications of Messrs. Doherty and Anderson. The Boston official is further reported to have testified that he thought the coal he had bought was of good quality "because nobody complained about it."

While the proposed specifications of the Geological Survey are a distinct improvement over previous methods, there is a good deal more to the valuation and quality specification of steam coal than the percentage of combustible. The dust at the bottom of a coal-bin must be just as high in combustible as the lump coal of which it is the residue, but it is not worth the same price per ton for use on boiler grates. Again, there is a grade of red-ash coal which may be equal to ordinary Pocahontas in combustible content, but with an "ash" so high in sulphur and iron pyrites as to form clinkers similar to blast-furnace slag and make the fireman's job a torture.

The Vertical Gas Engine

What is the insuperable obstacle in the way of building large gas engines in the vertical form? We are not considering the relative merits of the vertical and horizontal constructions, nor intimating that the former is preferable to the latter. We merely express a mild degree of surprise that although almost every gas-engine designer will tell you that large vertical engines are impossible, none of them has ever yet issued a rational explanation of the impossibility. One will tell you that proper cylinder lubrication is impracticable in the vertical machine; another, that equable cooling is out of the question; yet another, that the valve-gear design becomes unmanageable; all of which claims are utterly unscientific and groundless. One engineer of wide experience recently made the assertion publicly that he "knew there were problems to be solved in a vertical gas engine that did not exist in a horizontal gas engine," but he did not deign to enlighten his hearers as to what they were. We should like very much to know. We are perfectly familiar with the obvious fact that a double-acting tandem gas engine built in the vertical form would extend sky-ward to a most inconvenient degree, and we appreciate the difficulties entailed by this construction when dismantling becomes necessary, but we can conceive of no mysterious feature of the internal functioning of a gas engine which might serve as the basis for these frequent vague references to the impossibility of the vertical form.

Inaccuracy in Making Measurements

The operations of weighing and measuring are daily performed by thousands of more or less inaccurate men and instruments. Since all observations are affected by the faults of instruments and observers, it is interesting to consider the nature of the variations from the truth which appear in every series of observations. These may be classified under three heads.

The first class comprises "constant" errors, which are those due to inaccuracy in the measuring instrument used. In this class fall the errors of steam gages which read several pounds too high or too low; the errors of indicator springs, which seldom agree with the scale supposed to fit them and which differ more or less from the standard scale, according to the temperature of the springs themselves; the inaccuracies of measuring rules, the errors in scale weights and in the scales themselves, and the like. All such errors can be ascertained by comparison with an accurate instrument, and the imperfect one may then be used to measure with as well as the other. Thus, in a measuring machine or dividing engine, if the master screw or scale is carefully compared with an accurate reference piece, it may be found just how many ten-thousandths it is in error at each even unit or smaller fraction, and these changes may be added to or subtracted from the observed readings. Constant errors are therefore to be eliminated by comparing the measuring instruments with a standard and correcting the observed readings accordingly.

The next class of errors may be termed "blunders." In this class are placed such mistakes as setting down the wrong figure, though the right one was in mind, or missing a count in tallying loads of coal or tanks of water, or reading a gage or rule a foot or one hundred pounds out of the way. Blunders are just as likely to be very large as very small, so that the chances are rather in favor of a blunder being easily detected among other observations of a series. Thus in reading steam gages at fifteen-minute intervals during a long test any mistake of ten or one hundred pounds, or figures reversed in setting down, is conspicuous; though similar blunders may involve so small an error as to escape detection. An accurate observer makes no blunders.

The third class of errors are those of obsertation. These depend partly upon the skill of the man making the measurement, and partly upon the nature of the instrument used. They depend also upon the nature of the material or quantities being measured, it being obviously more difficult to weigh accurately a large bulk of sand, containing as it does an uncertain and varying quantity of moisture, than a small quantity of metal. In general, small quantities can be measured more closely than large ones, but not necessarily with a smaller percentage of error. Astronomers measure enormous distances with a greater degree of accuracy than is attained with the measuring instruments and quantities found in most machine shops.

Consideration shows that the error of observation is more apt to be small than large, so that of twenty successive measurements of a given quantity the majority will be found grouped closely together, and only a scattering few at a great distance from the true value. For ordinary purposes it is satisfactory to take a number of repeated measurements of a quantity and by adding the observed values and dividing by the number of observations to find the arithmetical mean and assume this as the true value. But it is not strictly correct to average in this way several observations of which one may be very far off and all the rest very close, because the one extreme value will affect the computed mean as much as one of the more nearly correct majority. The true value lies near the observations which fall closely together.

A Compound Vacuum System of Steam Heating

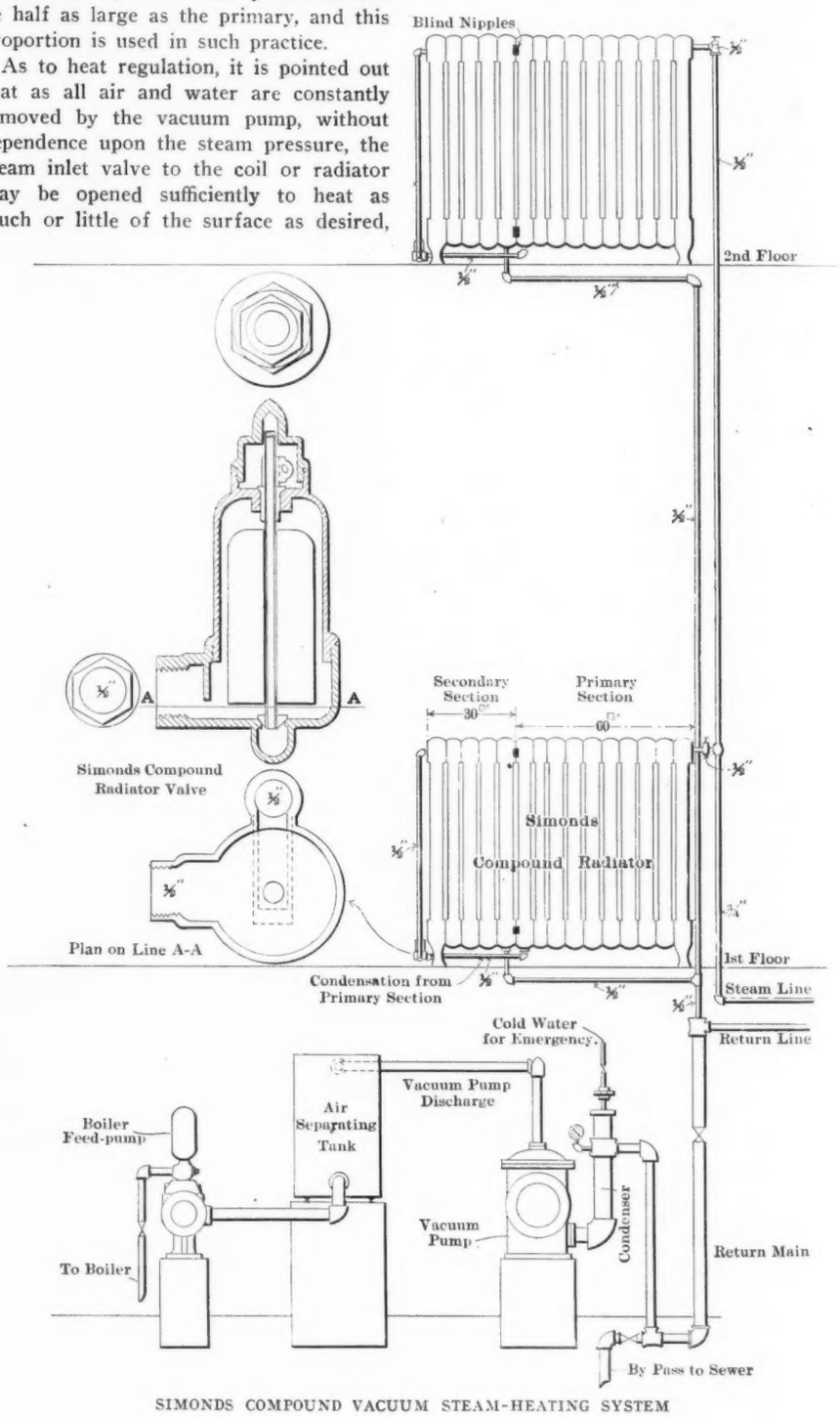
In general, a vacuum steam-heating system differs from the ordinary gravity-return system in the maintaining of a partial vacuum in the main and independent return pipes from each radiator or coil in the system. The partial vacuum is created and maintained by means of a vacuum pump, either steam or belt driven, and suitable vacuum devices are used in the return pipes, close to each radiator or coil, to permit the escape, from such radiator or coil, of the water of condensation and the air, at the same time holding back the steam. Steam and air will rush into a vacuum at many times the velocity of water. Owing to its friction the water of condensation is the most difficult element in the system to move or expel, and if a partial vacuum is maintained in the return pipes close to the radiator or coil, it acts continually as a suction and draws all air and water away, allowing the steam to flow into all parts, even though no perceptible pressure is maintained at the inlet end of the system.

In the Simonds compound system two sections of radiators or coils are used, one being termed the "primary or pressure" section, and the other the "secondary or vacuum" section. The primary section is supplied with steam and its return connected to the automatic vacuum valve. This valve is operated by a balanced float, under any reasonable steam pressure or any degree of vacuum. The vacuum of the secondary section extends through the hollow stem to the upper float chamber and valve. The air that is carried along with the water of condensation naturally collects above the water in the dome case, and until sufficient water accumulates in the case to float the valves off their seats they are both tight. When the float rises the lower valve discharges the water, and the air passes through the upper valve and is drawn down through the tube that forms the stem to which both valves and the float are fastened. The amount of air discharged, however, is regulated by an adjustable vent in this tube, the vent being usually about one-half of a 1/16-inch hole. By means of the clamped upper valve both valves can be adjusted tightly to their seats.

The lower valve has no guide-wings or pins to catch sediment, but the discharge is free, and as the bottom opening is ½ inch in diameter in the small size and ⅝ inch in the large, danger of clogging is reduced to minimum. Of course, no dirt nor foreign matter can get above the water line, so there is no danger of fouling even the small vent of the upper valve.

The water discharges from the vacuum valve into the secondary section, where a portion of it is re-evaporated, owing to the lower pressure maintained in this section. After condensing again it passes to the vacuum pump through the return line. No valves are used on the inlet or outlet of the secondary section, which acts as a surface condenser. It has been found that when operating under atmospheric pressure in the steam main, or ¼ pound above, and with 8 to 10 inches of vacuum in the returns, the secondary radiator can be half as large as the primary, and this proportion is used in such practice.

As to heat regulation, it is pointed out that as all air and water are constantly removed by the vacuum pump, without dependence upon the steam pressure, the steam inlet valve to the coil or radiator may be opened sufficiently to heat as much or little of the surface as desired, and this amount of surface only will be heated as long as those conditions exist. As may be conceived, such flexibility makes for steam economy, at the same time accommodating the needs of the occupant. To sum up the other advantages claimed for this system: The radiating surfaces are all effectual heating surfaces, no part being air or water bound; pressure can be reduced to that of atmosphere, or below; a complete circulation is secured even in the most distant parts of the system; all water hammer in pipes is obviated; water drippings and disagreeable odors from air valves are eliminated; coils or radiators are thoroughly drained at all times; in case exhaust steam is used, the back pressure on the engine or pump can be reduced to approximately zero. This system is built by the Simonds Heating and Specialty Company, Detroit, Mich.



SIMONDS COMPOUND VACUUM STEAM-HEATING SYSTEM

Power Plant Machinery and Appliances

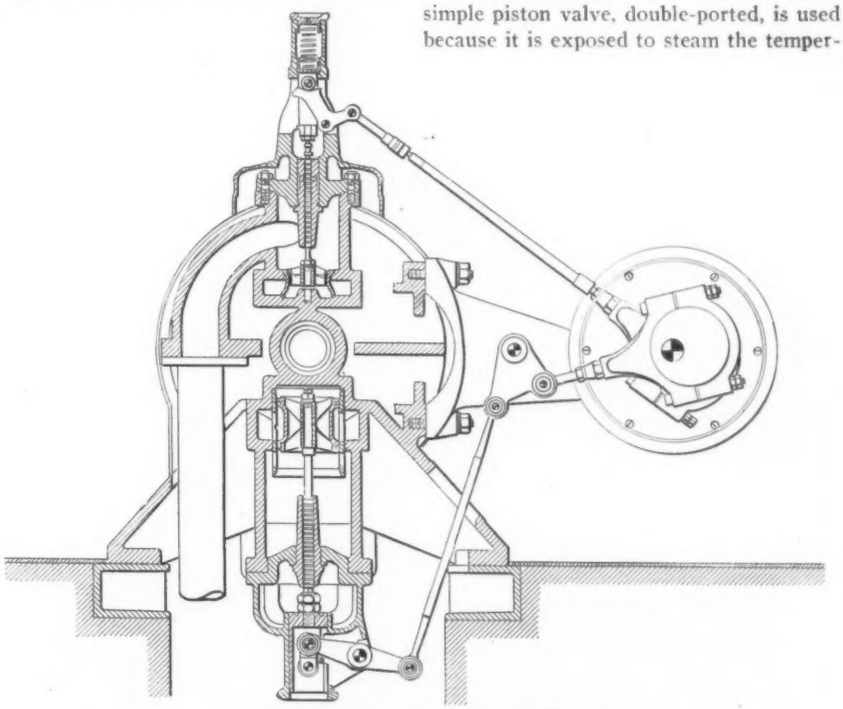
Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The New Bollinckx Engine

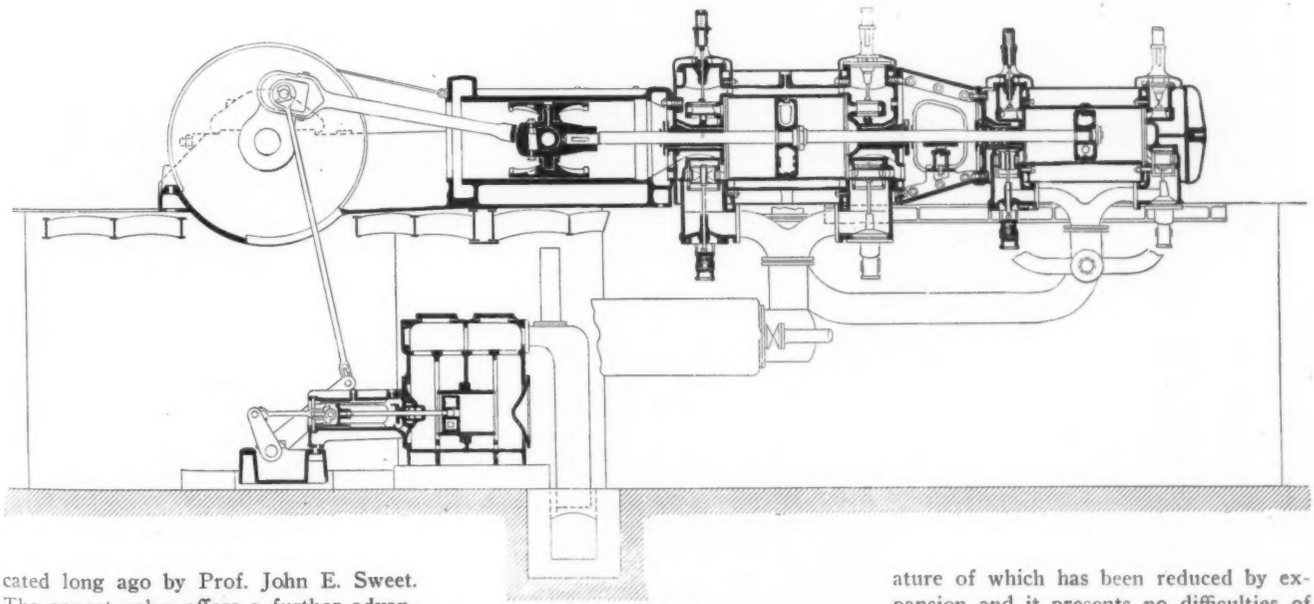
H. Bollinckx, the well-known engine builder of Belgium, known to our readers through occasional contributions to our correspondence columns, has revised his engine in accordance with the drawings reproduced herewith. After a trial of high rotative speed, as described in a former article, the works has returned to the model of 1902 which runs at 125 revolutions per minute, using a poppet valve for the admission and a piston valve for the exhaust.

The poppet valve consists of a simple ring with two seats, attached to its stem not by the customary rings but by overhead inclined bars resisting deformation due to changes of pressure and temperature. This type of valve offers particular advantages for use with high-pressure and especially with superheated steam. The stems of the valves have no stuffing-boxes, but work in long passages and have numerous grooves which, collecting oil and water, offer sufficient resistance to the passage of steam without the friction and the necessity of adjustment and renewal which attend the pressure stuffing-box. This is practically the construction advocated long ago by Prof. John E. Sweet. The poppet valve offers a further advantage of presenting a small surface to the entering steam and, arranged as in the engravings, provides ample edge opening upon its two seats and ample port area with a minimum of clearance. The operating mechanism is so arranged as to avoid inertia strains by starting the valve slowly from its seat, lifting it with a quickly accelerated motion to its full capacity, returning it rapidly to a point where it is almost in contact with the seat, and then seating it easily and without shock.



BOLLINCKX VALVES AND VALVE-GEAR

For the control of the exhaust the more simple piston valve, double-ported, is used because it is exposed to steam the temperature of which has been reduced by expansion and it presents no difficulties of lubrication. A simple form of shaft governor is used and for the connecting-rods 5½ cranks has been adopted as a standard. The valves are located in the cylinder-head.



THE BOLLINCKX ENGINE

The Bigelow-Hornsby Water-tube Boiler

The American rights to manufacture the Hornsby water-tube boiler, which has been on the English market five years, were recently acquired by the Bigelow Company, of New Haven, Conn., hence in this country it will be known as the "Bigelow-Hornsby" boiler. It has been re-designed in a measure, to meet the requirements of American high-pressure practice. A general idea of its construction may be obtained from Fig. 1, which shows a section through the setting. It will be noted that the boiler is supported entirely from the overhead beams, leaving the lower part free to respond to expansion stresses. The front tubes are inclined at an angle of 68 degrees, and the rear units are vertical, as shown. Only two lengths of tubes are used. Each section is independent of its neighbor, except the nipples connecting with the steam drum and the equalizing nipples which connect the bottom drums of the rear

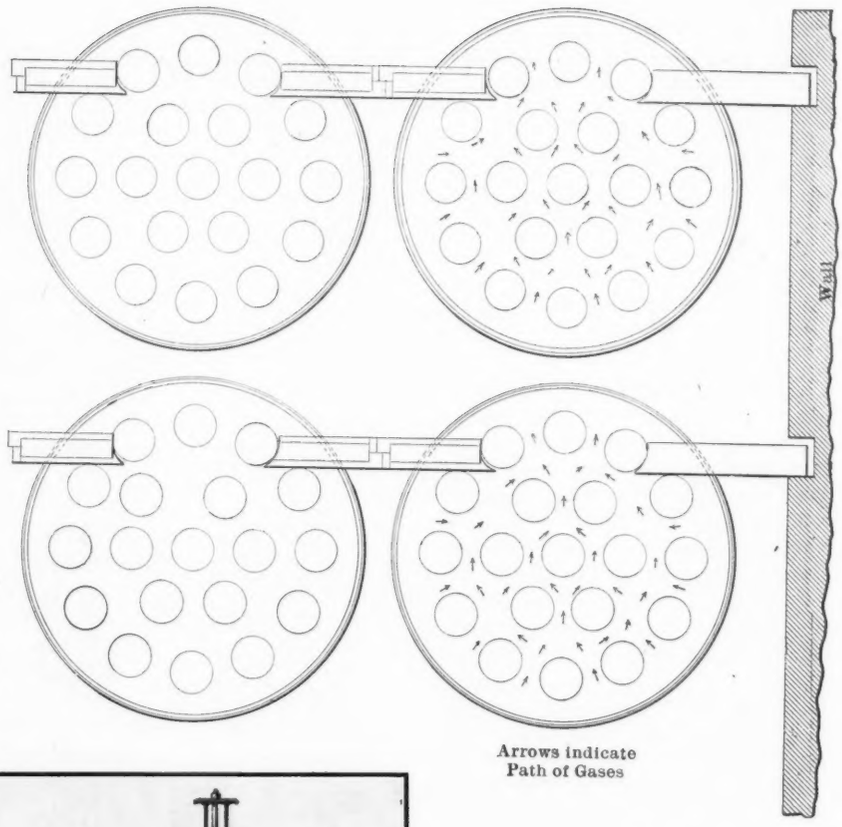


FIG. 2

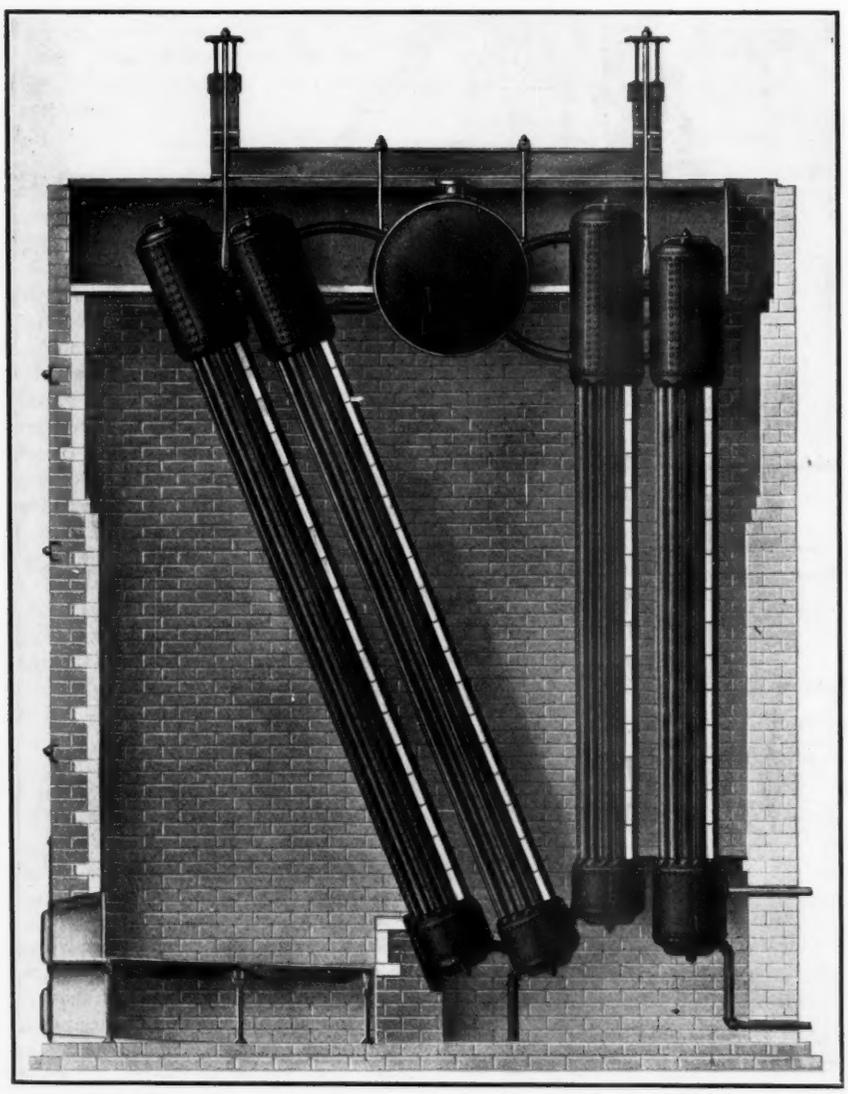


FIG. 1. SECTION THROUGH SETTING OF BIGELOW-HORNSBY BOILER

sections. This flexible form of construction permits the building of very large units, even larger than the 2200-horsepower Hornsby boilers at the Bow-street station of the Charing Cross & London Electricity Works, where four boilers containing 21,700 square feet of heating surface evaporate in regular service 110,000 pounds of water per hour. A large percentage of the heating surface is exposed to the radiant heat of the furnace, and to the first pass of gases, before these have reached any other heating surface. The tubes of the front unit which are located in front of the baffles comprise more than 12 per cent. of the heating surface of the boiler.

The feed-water is admitted into the bottom drum of the rear unit and is advanced gradually from the coldest to the hottest portion of the boiler, first passing up the entire length of the tubes in the rear unit, then from the top of those tubes to the unit immediately in front, down this unit and up the two front units and back through the steam drum to the first vertical unit at the rear of the steam drum. There is also, as may be conceived, a rapid local circulation in each of the units while the general circulation is going forward. The speed of the feed-water up the rear unit being regulated by the amount of steam generated, ample time is permitted for sediment and scale-forming matter to be deposited in the bottom drum of this unit. All liberation of steam from the water surfaces takes place in the upper drums and is

entirely unrestrained, the full area of the tube openings communicating with the drums. The transfer of steam and water between units occurs through separate nipples, and the water nipples are required merely to care for the general circulation through the boiler.

The arrangement of this boiler is such that it can be baffled so that the products of combustion are carried uniformly over the heating surfaces in thin layers, there being no large unrestricted paths parallel to the heating surfaces through which the gases can flow in their passage to the uptake. Fig. 2, which is a horizontal section through some of the rear units, shows how they are arranged with reference to the gas currents, and how the baffle-plates serve to guide the gases through in substantially uniform passages.

The smoke flue can be taken off at the back of the boiler at any point between the top and bottom. All the tubes are straight and every tube in each section can be reached for cleaning by the removal of a single manhole cover.

The boiler is built to a factor of safety of five for 200 pounds working pressure, and it is stated that a test section has been subjected to hydrostatic pressure of 1000 pounds without rupture. The ratio of grate surface to heating can be made as low as 1 to 26.

"Nyflexmet" Expansion Joints

The utmost expansion and freedom of motion could be obtained in a high-pressure pipe line by breaking the line at some point, leaving the end free in space; and this, figuratively speaking, is what it is aimed to do by means of the "Nyflexmet" compensators, which have just been placed on the American market by the New York Flexible Metallic Hose and Tubing Company, of New York City, and which are illustrated herewith. At some suitable place the continuity of the line is broken, and the two ends are connected by proper lengths of flexible, metallic hose, forming a pressure-tight union with each pipe, but in no way obstructing their movement endwise, because the connector is put in at right angles to the line. In one respect the flexible insert is similar in action to the leather part of a bellows, offering no obstruction to movement between the top and bottom. This insert piece is made of "Nyflexmet" hose, which for expansion joints for steam and other high-pressure pipe lines is composed of steel or copper ribbons, spirally wound, with interlocking edges, as shown in Fig. 1. Asbestos packing is placed under the edge lips to insure tightness, while the metal wall is further strengthened by a single or double sheathing of flat, pressed-steel wires, woven to conform to the surface.

FIG. 1

Special cast-flanged connectors form the joints between the main pipe line and the "Nyflexmet" movable expansion pieces, these joints being suitably packed, and their flanges united by through-bolts, which not only set out the packing ring, but also serve to reinforce the taper grip which has been provided in the connector casting to secure the woven-steel sheathing of the hose section firmly in position. It is declared to be impossible for any pressure to pull the connectors off the "Nyflexmet" hose, as they are screwed in so firmly that the hose would burst first, and no thread need be cut in the hose for this screwed connection, as its spiral construction serves the purpose of a continuous thread.

"Nyflexmet" joints are useful in cases where a pressure-carrying line must be run between points the distance between which is subject to variation, and some provision must be made to compensate for such change of length, as in connecting portable boilers to engines, in running lines of piping on docks subject to heavy jars, and in temporary steam and compressed-air lines used in building and engineering operations. The construction of "Nyflexmet" expansion joints is modified to suit each case, and furthermore, this arrangement renders it possible to make any naturally occurring bends or branches in the line of pipe useful in allowing for expansion and contraction by inserting one or more of these joints, instead of introducing spring elbows or other bends not otherwise requisite.

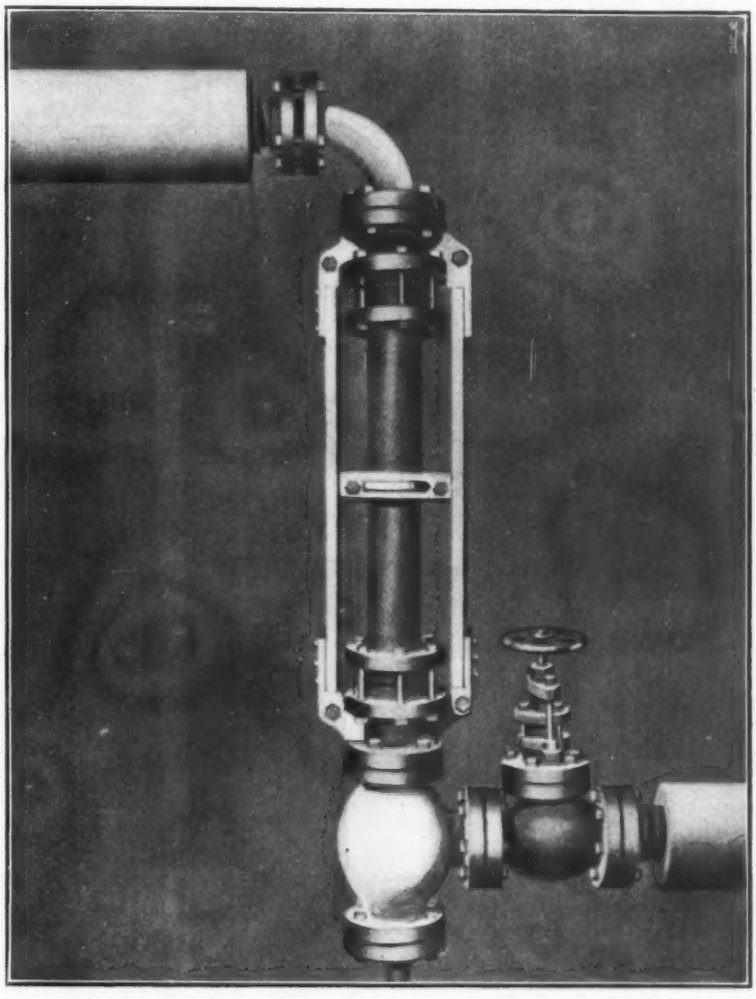


FIG. 2. ONE APPLICATION OF "NYFLEXMET" COMPENSATOR

For straight lines, Z-shaped expansion joints are provided, as well as U-shaped joints, equipped with one or two flexible-hose legs, as may be deemed advisable. Single I-shaped expansion joints are inserted when the line of piping which is to have its expansion provided for must be connected into a second line running at right angles to it.

Due provision is made for limiting the

distortions and stresses to which the "Nyflexmet" hose may be exposed. Rods are disposed at either side, passing through and connecting with a pipe clip secured to the hose leg at mid-length. The combination forms the so-called "limiting parallelogram," designed to prevent straining of the hose by distributing uniformly throughout its length any bending stresses to which it may be subjected, causing it to bend S-wise. In addition, "Nyflexmet" hose is said to be capable of resisting pressures up to 900 pounds per square inch, and more, for pipes up to 8 inches internal diameter.

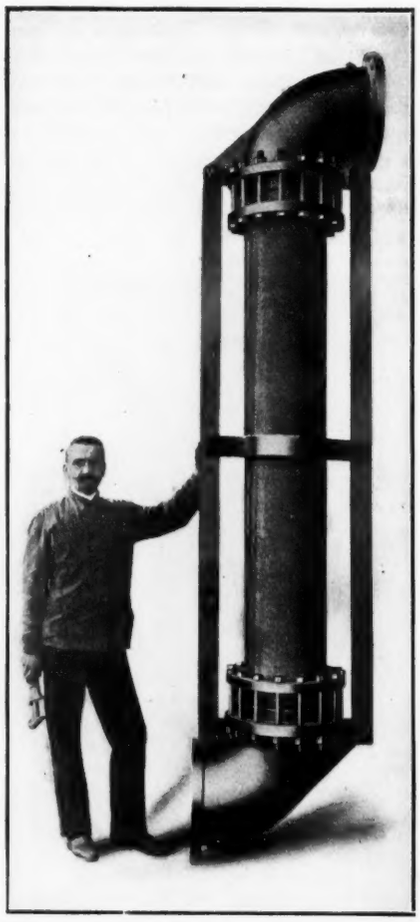


FIG. 3. LARGE-SIZED "NYFLEXMET" JOINT

For low-pressure installations, the construction is materially modified, inasmuch as the metal hose without woven-wire sheathing may be used, and the flange connections may be cast to the hose by means of white metal.

It is pointed out that the metal-hose expansion joint offers excellent facilities for repairs, as it is never required to renew the entire joint, and at the utmost one or two easily connected parts have to be inserted.

Fig. 2 shows a typical installation of an I shaped "Nyflexmet" compensator, with elbow, in a high-pressure steam line. Fig. 3 shows one of the larger sizes in which these compensators are made, and gives an excellent idea of the details of construction.

"Clean-seat" Valves

"Clean-seat" is the name applied to a type of valve which has just been put on the market by the Pittsburgh Gage and Supply Company, of Pittsburg, Penn. The "clean-seat" feature provides for blowing a strong jet of steam, water, air or other fluid across the valve seat and disk faces, when closing the valve, to prevent lodgment of sediment. A hollow cylindrical extension beneath the disk settles loosely in the seat opening as the valve closes and throttles the main flow, while a jet continues to blow across the seat and the face of the disk through a slot which extends all the way around the bottom of the extension, below the disk face. This jet continues to blow across the meeting surfaces until the valve is completely closed. There is, therefore,

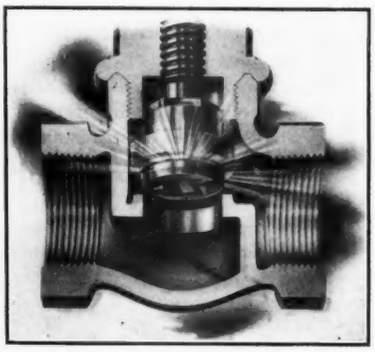


FIG. 3

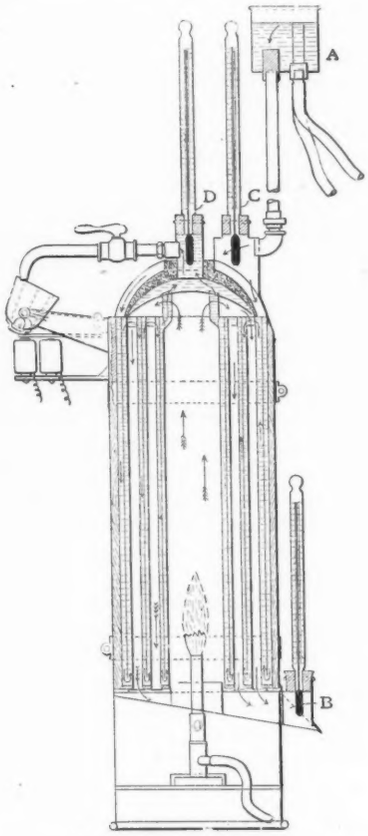


FIG. 1. SECTIONAL VIEW OF THE SARGENT GAS CALORIMETER

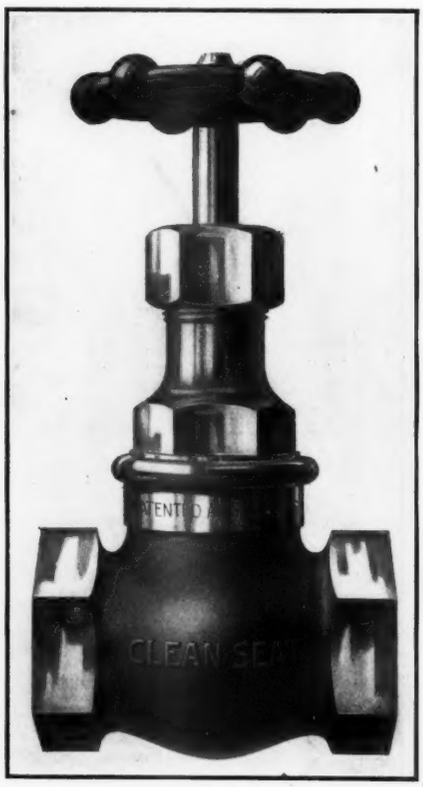


FIG. 1

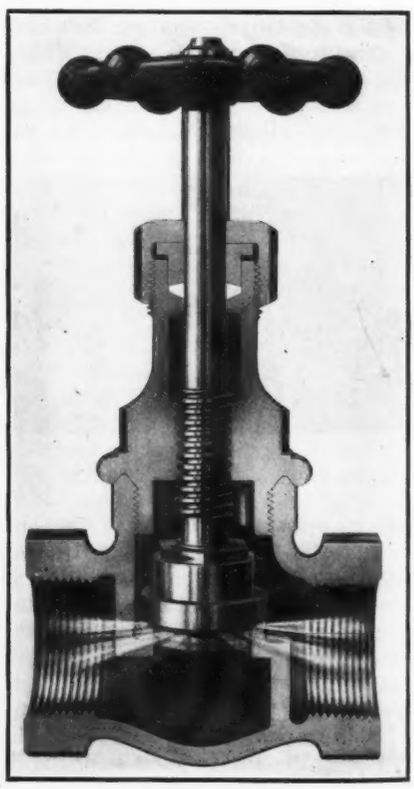


FIG. 2

no danger of the surfaces being cut, either by the lodgment of foreign matter or by the action of the jet. The stem may be packed with the valve open, as the top of the valve disk is faced to seat perfectly against the bottom of the bonnet. The bonnet is strong, with a long thread entering the valve body, the V joint between bonnet and body insuring a fit.

"Clean-seat" valves are made in globe and angle patterns, of brass, for all classes of medium, extra heavy and hydraulic work. The same principle of construction is applied to the "clean-seat" blow-off valve for boilers, also recently placed on the market.

The Sargent Automatic Gas Calorimeter

Fig. 1 is a sectional view of a Sargent automatic gas calorimeter as made by the Sargent Steam Meter Company, of Chicago. In this instrument the cold water enters and the warm water discharges at the top, which permits the adjacent location of the thermometers most frequently read. The cistern *A* furnishes a constant head for the inlet water, the temperature of which is taken at *C*, and which in its passage, in the direction of the arrows, envelops the instrument and absorbs any heat radiating from the water that is being heated. The rise in temperature is indicated at *D*. The thermometers read in tenths of a degree Fahrenheit.

The combustion of the gas takes place in the central flue and the products of combustion pass to the top and down the annular chambers, as shown; they reach the temperature of the water before they pass out at *B*, where a damper regulates the velocity and a thermometer gives the temperature of the exhaust products. To insure steady combustion the gas pressure is controlled by means of a pressure regulator with micrometer adjustment, and the Bunsen burner is protected from draft on all sides of the base except the front.

To afford continuous determination, as well as to obviate possible error by the operator, the water is changed automatically from one receptacle to another when one-tenth of a foot of gas has passed through the meter. Also to eliminate likelihood of error, the outlet water is weighed.

Fig. 2 shows a complete calorimeter layout, including apparatus used with producer and blast-furnace gas, such as a dust filter, tar extractor, moisture eliminator, etc.

A New Float

Herewith is shown a steam-trap float recently patented by Walter A. O'Brien,

A NEW FLOAT

of the Templeton Manufacturing Company, 22 Randolph street, Boston, Mass.

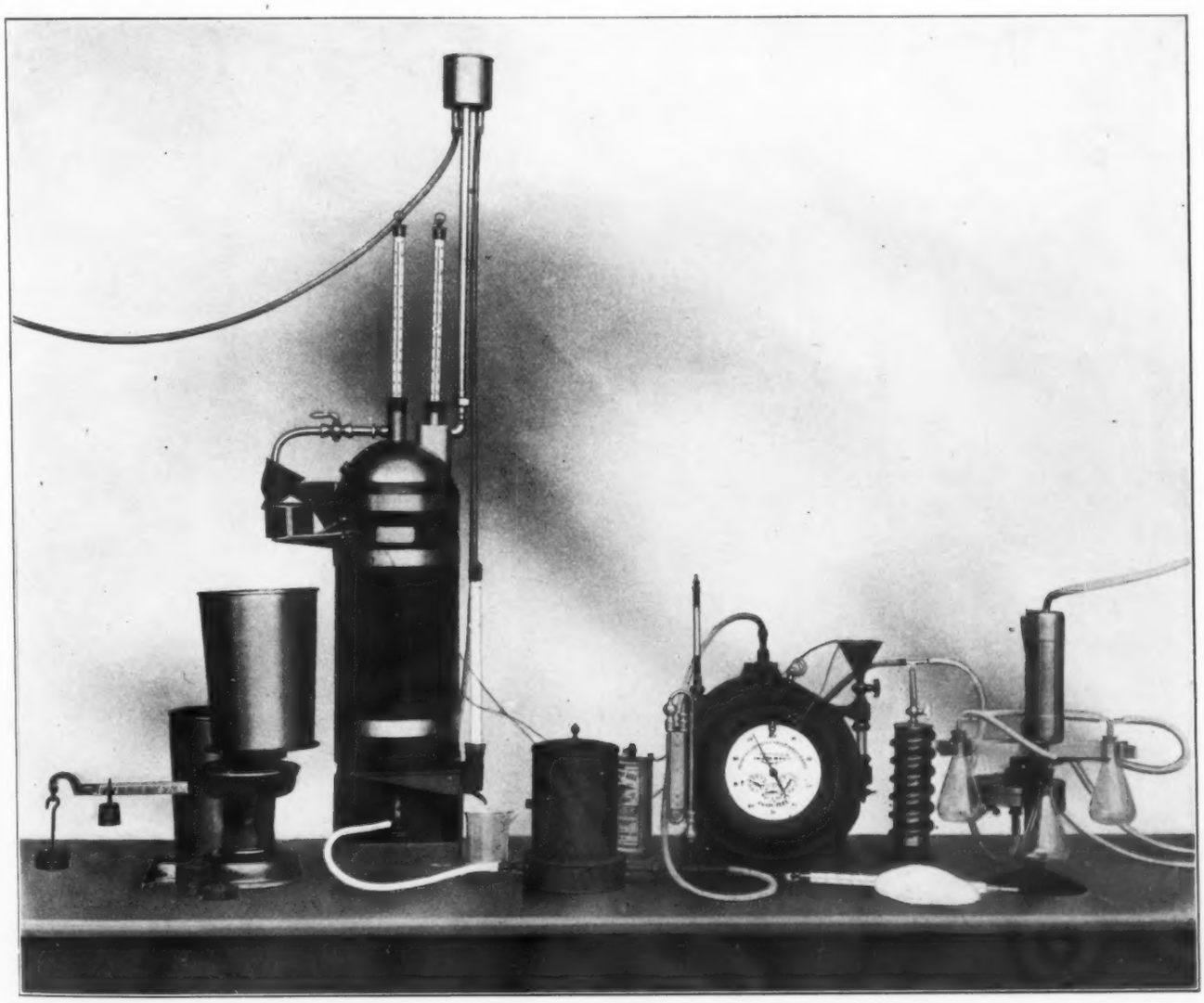


FIG. 2. THE SARGENT AUTOMATIC GAS-CALORIMETER OUTFIT COMPLETE

The distinguishing features of this float are the means provided to resist pressure. Each of the two hollow sections is provided with an outwardly extending flange having a lateral lip, the lip of one being bent over the other lip and soldered, the joint being reinforced by a pressure-resisting ring soldered in the seat formed by the opposed flanges and the inner lip.

There is an axial opening in one section to admit a longitudinally adjustable compression-strut, or brace, the stem of which projects through the opening and permits adjustment after the sections are soldered together. Disk-like ends, faced with solder, abut against the inner surfaces of the shell, being joined thereto by means of heat applied externally, and straps or bands pass about the float and interlock with the stem of the brace, making it doubly secure.

The Crosby Detent Motion

The latest form of detent motion adopted by the Crosby Steam Gage and Valve Company, Boston, Mass., is shown in connection with their reducing wheel in the accompanying engravings. The motion is received from the crosshead upon the aluminum drum *A*, a guide moved upward and downward by a screw upon the central shaft leading the cord on fairly. The bevel gear transmits the motion to the member *B*, reduced in the ratio of 1 to 4. The member *C* is loose upon the shaft and is driven from the

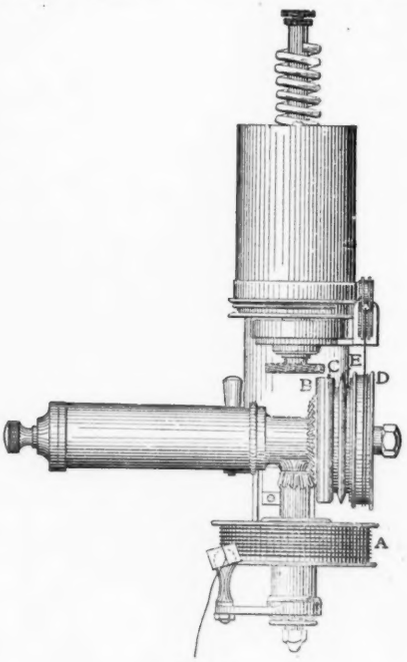


FIG. 1

member *B* by the contact of an internal pin against which the stop on *C* is held by the tension of the indicator-drum spring, acting through the cord which connects the reducing wheel with the indicator.

Between the plate *C* and the changeable sheave *D*, but of a part with or attached to both, is a thin plate *E*, which the split-jaw *F* is made to seize when it is desired to arrest the movement of the indicator barrel. The jaw sets upon the plate in such a way, evident from the engravings, that the movement of the plate can continue as the cord is running out, but will be arrested when the crosshead starts to return. The paper barrel is, therefore, held stationary with its spring in tension, holding its cord tightly about the sheave of the reducing motion, which latter is held against the pull of the spring by the jaw clutching the plate to which it is attached. In the meantime the cord between the crosshead and reducing motion is winding and unwinding upon and from the receiving drum, being kept taut by the tension of the helical spring in the horizontal cylindrical case. There is, therefore, no need of a take-up motion.

When it is desired to start the drum the pawl is lifted, releasing the plate which allows the member *C*, consisting of the

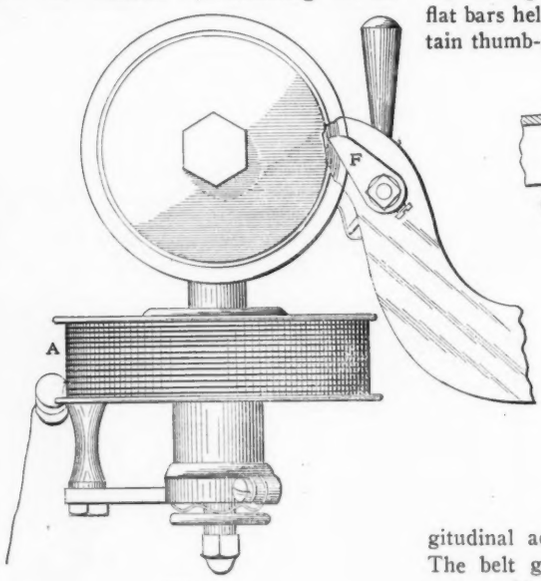
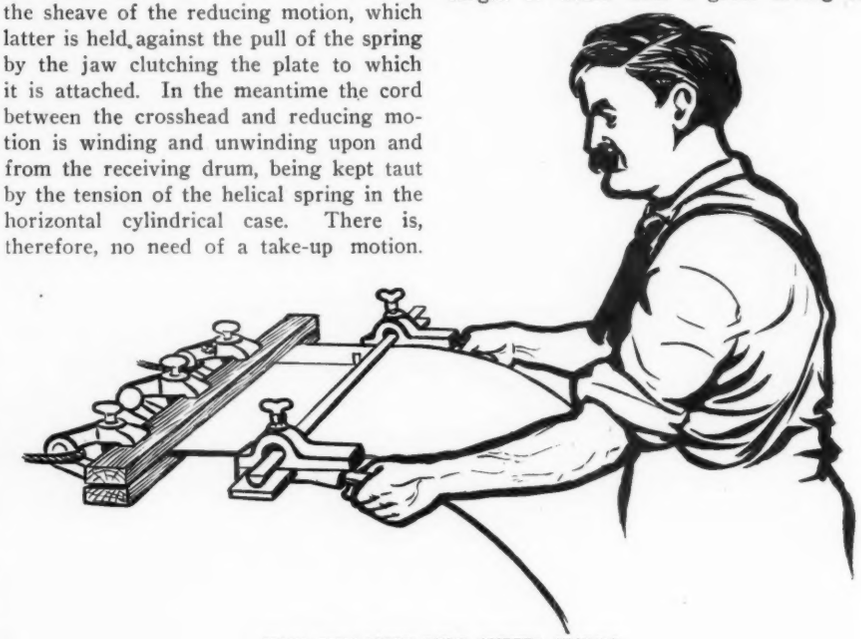


FIG. 2

clutch, plate and sheave, to turn backward until the clutch engages, when the movement of the drum is again under the control of the crosshead. If the operator releases the pawl when the crosshead is at the end of its outward stroke, the pins of the clutch will be in contact and the motion will be resumed smoothly and quietly, with no snap-back and no loosening of the cord. The pawl is retained in or out of engagement by a spring of peculiar shape acting upon a pin, as shown in Fig. 3.

The More Belt Cutter

The More belt cutter is designed to cut single or double belting into any ordinary length or width with a great saving of



HOW THE MORE BELT CUTTER WORKS

time over ordinary methods. The machine is very simple and easily adjusted. As the engraving shows, it comprises two flat bars held in handle clamps, which contain thumb-screws for the lateral and lon-

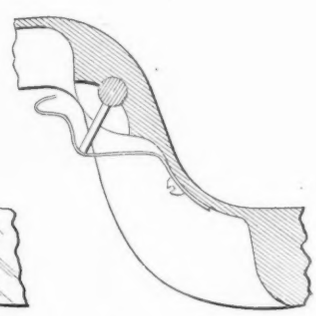


FIG. 3

gitudinal adjustment of the flat strips. The belt goes between the bars, and a cutter, aided by manual effort, does the rest. Clamp the end of the belt to a stationary support, adjust the cutter and pull —that is all there is to it. By this means any width of belt up to 16 inches is obtainable. Phillipps & Troup, Dayton, O., are selling agents for the More belt cutter in the United States and Canada.

"Universal" Hydraulic Jack

The hydraulic jack illustrated in the accompanying engravings is the latest product of the Richard Dudgeon shops, at Broome and Columbia streets, New York. As will be seen by the sectional view, Fig. 1, this is a double-pump jack. With both pumps in action a jack of 30 tons maximum capacity will lift a load of 15 tons at a rate of 1 inch in every six strokes. With only the lower pump working, 30 tons may be raised 1 inch with every 12 strokes. When the valve handle is in the position shown in Fig. 1, the cam at the end of its shaft, shown more plainly in Fig. 3, allows the push-tube, shown separately in Fig. 5, to be held up by the coiled spring at its lower end so

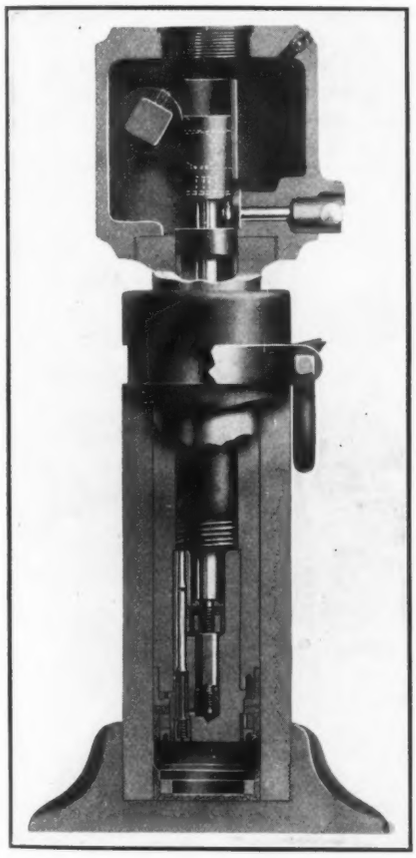


FIG. 1. SECTIONAL VIEW OF "UNIVERSAL" HYDRAULIC JACK

that all the valves shown in detail in Fig. 4 are free to seat. When the valve handle is turned down to a vertical position the cam is revolved sufficiently to unseat the upper valve so that the upper piston ceases to work, the liquid displaced simply surging back and forth through the open suction valve. Turning the valve handle to the opposite horizontal position unseats all of the valves, allowing the cam to descend by its own weight; or the jack to be lowered by means of the operating lever, by depressing the arm until a pin projecting from the lower side of the piston-head encounters the top of the push-tube, when it performs the same office as the cam on the valve-handle shaft. The push-tube, Fig. 5, serves two purposes, to throw out the auxiliary pump and to force the valves from their seats in order to lower the plunger or to clear the valve seat. Inasmuch as the valve bore and

FIG. 2. EXTERIOR OF JACK

cam are off center, a tube is more suitable for this purpose. It is a sectional boiler tube with one end swaged to provide a seat for the spring and a contact for the valve, and it may be slotted as shown to

FIG. 3. CAM, SHAFT AND VALVE HANDLE

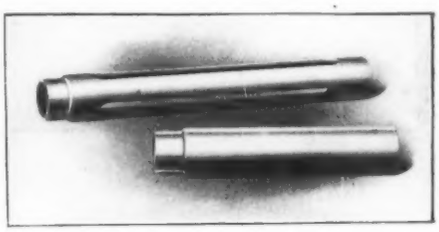


FIG. 5. THE PUSH-TUBE

ber, but one pressure and two suction valves being used, and of the suction valves but one being used at a time. It is universal in its application, may be used in a horizontal as well as a vertical position, and with the handle pointing in any direction, the suction valves remaining submerged whatever its position may be. The simultaneous use of the two pumps allows the jack to be quickly run out when adjusting it to the load and permits the

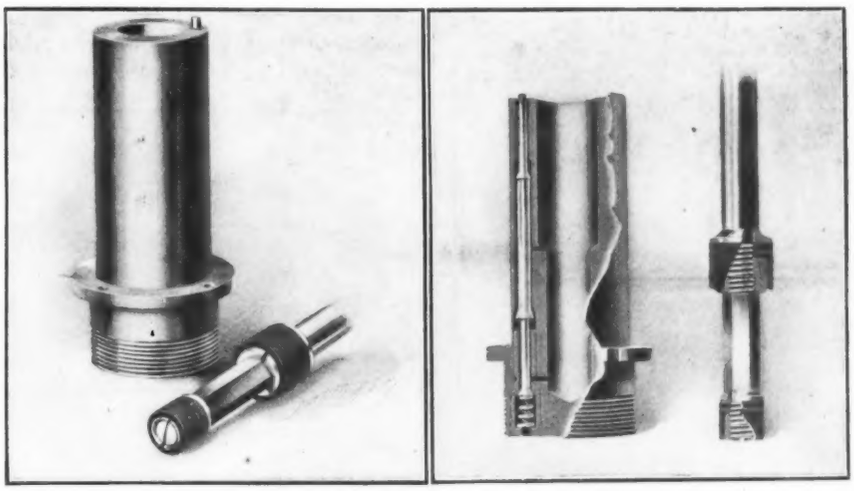


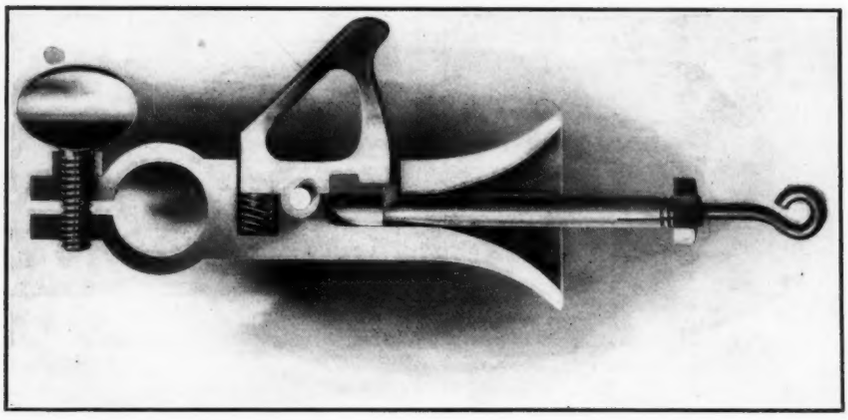
FIG. 4. SHOWING DETAILS OF THE VALVES

decrease weight and displacement. The upper end is hardened to resist the wear of the cam.

The special feature of this jack is the assembling of the valves in the valve chamber and the reduction of their number, but one pressure and two suction valves being used, and of the suction valves but one being used at a time. It is universal in its application, may be used in a horizontal as well as a vertical position, and with the handle pointing in any direction, the suction valves remaining submerged whatever its position may be. The simultaneous use of the two pumps allows the jack to be quickly run out when adjusting it to the load and permits the rapid handling of the lighter weights, while the control of the lowering by the lever as well as by the handle enables the operator to work to the best advantage. Fig. 2 is an exterior view of the jack.

Attaching Device for Indicators

The attaching device shown in the accompanying engraving is the invention of John Devine, one of the oldest erecting men in the employ of the Atlas Engine Works, and forms a part of the regular equiment send out by that company for the use of its erecting engineers. The trumpet-shaped member is of aluminum and is clamped to a ⅜-inch pipe which is screwed into the crosshead, or to the point from which the motion is to be taken. The cord is attached to the ring, which is inserted in the split-tube with a taper thread, so that it is clamped by running the nut up, and forms an easy adjustment for the position of the diagram upon the paper cylinder. To set the indicator in motion it is necessary only to hold the spear-headed end of the arrangement to which the cord is attached, so that it will slip into the trumpet as the latter comes along, and be caught by the latch; and to detach, it is necessary only to touch the finger upon the trigger as it passes. The device is not patented nor regularly upon the market, although we presume the inventor who designed the rig for his own convenience could furnish it upon application.



ATTACHING DEVICE FOR INDICATOR CORD

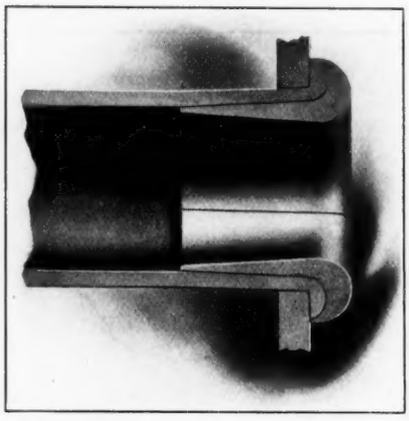


FIG. 1. SHOWING PROTECTOR IN PLACE

Cruise's Expanding Boiler-tube Protector

Here is a little device designed to reinforce the worn ends of boiler tubes, thereby closing any leaks that may be due to expansion of the thin tube-end, or to corrosion, and to shield the end of the tube from further damage. This protector is, in effect, a ferrule, slightly tapering on the outside and with the end that goes into the tube shaped to form a thin edge, while the outer end is beaded, or flanged, to fit over the tube flange, as shown in Fig. 1. The ferrule is split longitudinally, as shown in Fig. 2, a wedge-shaped section being removed and a key, also shown in Fig. 2, substituted, the idea being that after the ferrule has been inserted and the right-sized key driven home, the contact between the ferrule and tube-end will be as close as possible.

These protectors are made of malleable iron, which permits of considerable expansion, so that keys of different sizes may be used to expand the ferrule to conform to the tube, and four keys are provided with each ferrule. The Cruise protector is made by Cruise & Co., 873 Livingston street, Elizabeth, N. J.

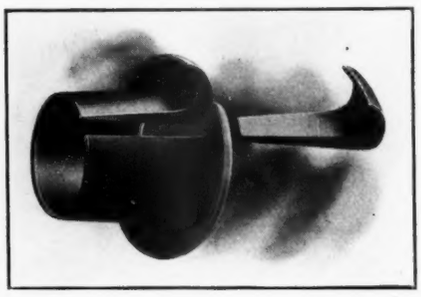


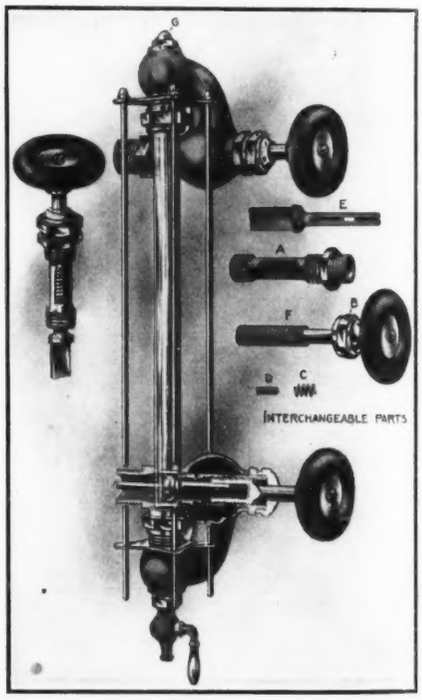
FIG. 2. SHOWING SLOT IN FERRULE AND KEY

The Stulp Safety Water Gage

The water gage illustrated herewith is known as the "Stulp Safety No. 1." It is made by the Automatic Safety Water Gage Company, Fred J. Stulp, proprietor, of Muskegon, Mich. It is designed to close automatically if the glass breaks, and to be self-cleaning and self-regrinding, and it has a "long-range" water glass. Reference to the cut will show that the valves seat from the inside, or directly opposite from old-time practice, but as the valve-stem has a left-hand thread, the hand-wheel operates in the usual way. To remove incrustation from the valve seat, all that is necessary is to operate the hand-wheel a few times, which serves to regrind the valve on its seat.

The "long-range" attachment for the gage glass consists of elbows, or goose-neck pipes, located at the top and bottom of the gage body, permitting the use of a glass four or five inches longer than ordinarily, without relocating the holes in the boiler or water column.

The removable valve case *A* has a threaded inner portion to admit the hand-wheel stem *F*, which contains a hollow chamber for the admission of the valve-stem *E*. There is a small screw-hole in the hand-wheel stem to admit the screw *D* which holds the valve-stem in position. A spring *C* in the chamber of the hand-wheel stem holds the valve from its seat in ordinary use. The threaded ends of the case *A* are of the same pitch but of different diameters, so the small end will pass by the outer thread in the gage body when the tube is being inserted or removed. There is a threaded pocket on the opposite wall of the interior of the gage body to receive the small end of the case *A*, and both threads engage those in the gage body at the same time, insuring uniform lead and a good fit.



DETAILS OF THE STULP SAFETY WATER GAGE

Ample steam and water passages are provided to prevent corrosion and the collection of sediment. The arrows indicate the direction of passage of the water and steam from the boiler, through the gage and into the glass. There is a flat projection, which serves as a scraper, on the valve-stem to loosen sediment in the boiler connection. It revolves with every turn of the stem. The packing nuts for both the hand-wheel and gage glass are provided with friction rings.

The gage glass can be changed from left to right by transferring the top section of the gage to the lower hole in the boiler, and the lower section to the upper connection, and exchanging the positions of the waste-cock and the removable plug *G*. Another advantage of the plug *G* is in its easy removal on occasion of replacing the glass, the hole being large enough to admit a ¾-inch glass.

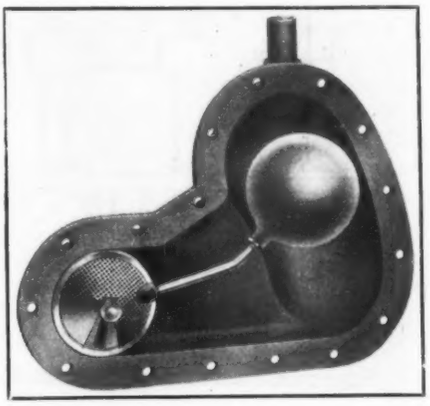
When it is necessary to take the gage apart the case *A* can be removed without disturbing other connections, then the screw *D* is taken out, thus releasing all the parts.

The Webster Grease and Oil Trap

This trap is made by Warren Webster & Co., of Camden, N. J., for use in connection with oil separators and feed-water heaters under ordinary non-condensing conditions. As indicated by the sectional view herewith, it comprises two flanged castings, one of which contains the inlet and outlet ports and the valve mechanism, while in the other casting a hand-hole is located, directly facing the valve.

The valve mechanism consists of a copper-ball float, attached by a connecting lever to a brass disk which contains a triangular port and which turns upon a cast-iron seat in which there is a corresponding triangular opening. The valve section is completely covered by a brass, bowl-shaped coarse screen held in position by the nut of the valve bearing. This screen also acts to steady the valve parts, pressing against them lightly.

In operation the oily drip enters the trap through the pipe shown at the top, a pet-cock being opened to allow the air to escape, and afterward closed as the filling proceeds. The rising liquid lifts



THE WEBSTER GREASE AND OIL TRAP

the ball float which causes the valve disk to turn, exposing more and more of the port until the opening is entirely uncovered and the liquid proceeds to waste or empties into a receptacle, the outlet equaling the full volume of the inlet. Thus the position of the valve is regulated solely by the rate of inflow, so that normally there should be no danger of a "blow through" from the trap.

The screen is of a mesh coarse enough to permit the oily drip to pass through it easily while particles of packing or waste are held back. When the screen becomes clogged, it can be readily reached through the hand-hole. This trap is made in all standard pipe sizes from ¾-inch to 2½-inch, inclusive.

Branch Valve Models

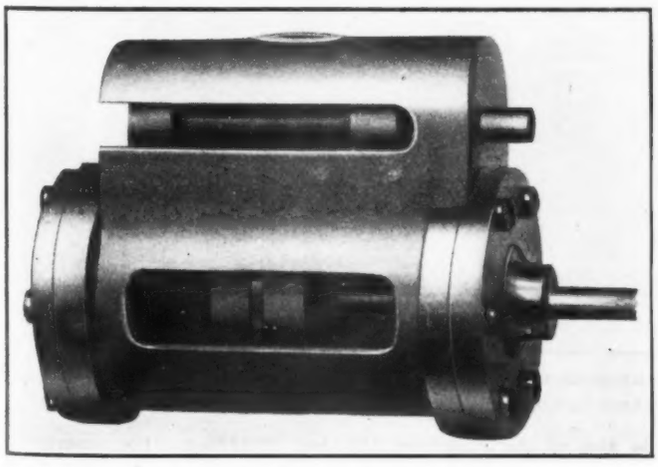
We illustrate herewith slide- and piston-valve models which have been designed by Joseph G. Branch, long identified with the steam engineering profession as inspector, examiner and author. The models are intended for use in the school room and by the student of steam engineering, as well as operating engineers, to make clear to their possessors the valve action of a steam engine, what is meant by outside and inside lap, lead, cut-off, valve travel, clearance and stroke; also to demonstrate how to set the valves, and the effects of early and late cut-off. The proportions of practicable engines have been preserved in the models, that of the slide valve being 4¼x3½ inches and that of the piston valve being 3¾x3½ inches. Each weighs one pound. They are made of aluminum throughout, and are very durable. They may be obtained of the National Equipment Company, of St. Louis, Mo.

"Swartwout" Gravity-closing Ventilator

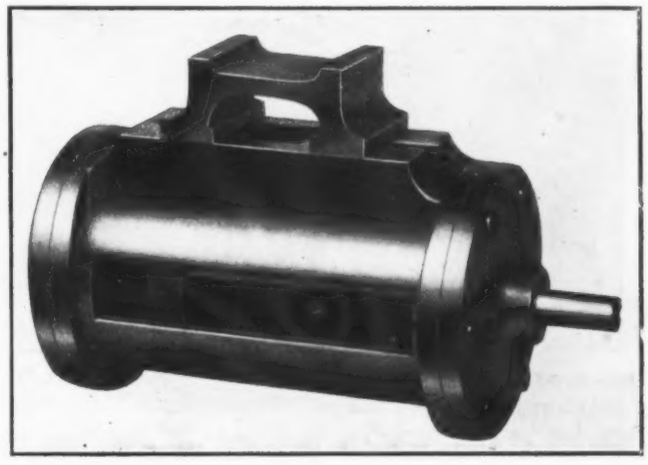
The sectional view shows the construction of the special features of the "Swartwout" ventilator—the sliding damper, with

"SWARTWOUT" GRAVITY-CLOSING VENTILATOR

conical cap, the guide-rod down which it slides by gravity, and the chain and cast-iron pulley for raising it again. As



THE BRANCH PISTON-VALVE MODEL



THE BRANCH SLIDE-VALVE MODEL

will be seen, the cap overhangs the edge of the flue, making it weatherproof and preventing dust from entering. The damper top is mounted on a heavy, iron sleeve which slides loosely enough on the guiding rod to prevent binding. The device is practically noiseless in operation.

The "Swartwout" ventilator is the product of the Ohio Blower Company, of Cleveland, Ohio.

Anderson Cushioned Non-return Valves

Figs. 2 and 3 illustrate types A and B Anderson cushioned non-return valves which, used in combination with the Anderson pilot valve, as shown in Fig. 1, form what the maker calls "emergency stop-valves," designed to operate automatically in case of accident, such as the bursting of pipes, fittings, valves, etc., which would cause the steam to fill the engine and boiler rooms, making it impossible to shut the valves by hand. These valves are triple-acting, angle or globe, and built for 350 pounds working pressure. Reference to Figs. 2 and 3 will show very clearly the mechanical construction, which embodies the well-known characteristics of the Sanderson products in general, including the Corliss dash-pot method of cushioning, as pointed out in previous descriptions.

Fig. 4 is a sectional view of the Anderson pilot valve, which is simple in construction. A steam connection from the main steam line to the top of a copper diaphragm (see Fig. 1) holds the pilot valve closed, because of the large area above the diaphragm. A steam-pipe connection from underneath the emergency piston of the triple-acting non-return valve leads also to the pilot valve. In case a break occurs in the main steam line or branches, the pressure is removed from the top of the pilot valve, causing it to open forthwith, exhausting the pressure from beneath the emergency piston in the triple-acting valve. The boiler pressure on top of the emergency piston causes the valves to close. Normally, of course, the boiler pressure is on top and underneath the emergency piston so that it is always balanced until rupture occurs. The pilot valves may

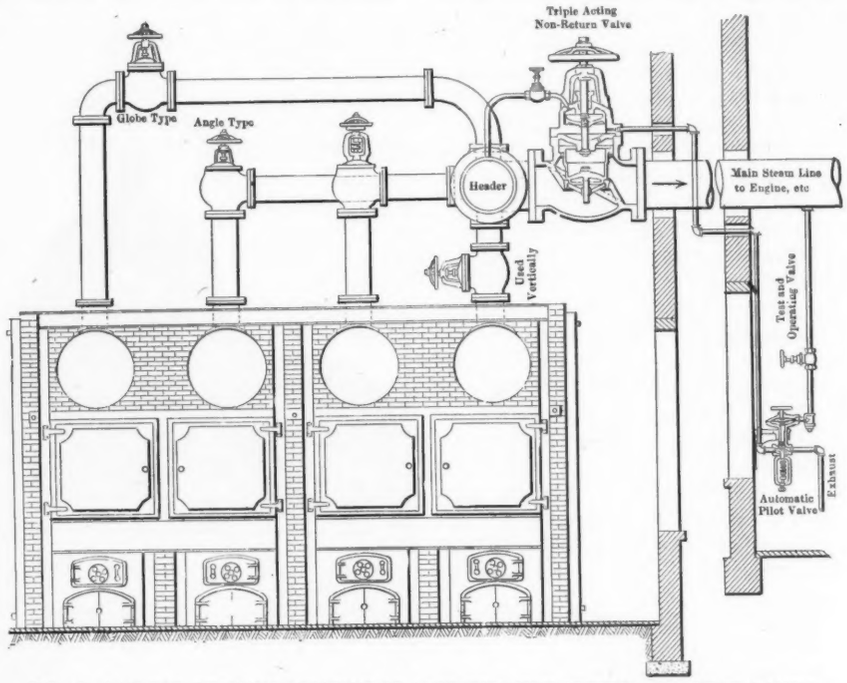


FIG. 1. LAY-OUT SHOWING LOCATION OF ANDERSON NON-RETURN AND PILOT VALVES

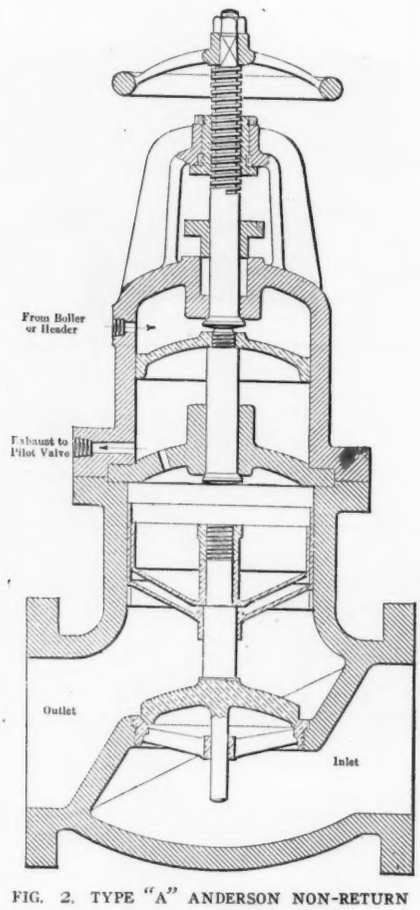


FIG. 2. TYPE "A" ANDERSON NON-RETURN VALVE

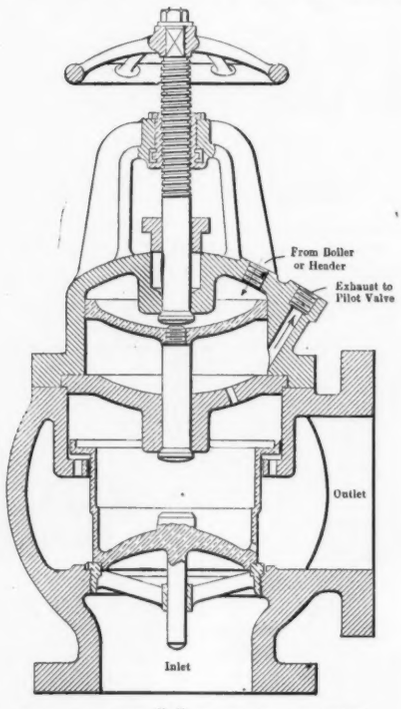


FIG. 3. TYPE "B" ANDERSON NON-RETURN VALVE

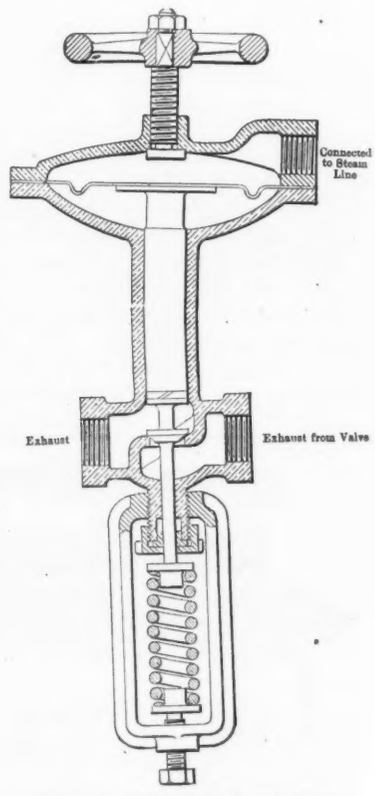


FIG. 4. ANDERSON PILOT VALVE

be located at any desirable place, thus affording control from different points. Steam from boilers can also be shut off from different points by having small emergency lines fitted with regular globe valves, in addition to the pilot valve.

These valves are made by the Golden-Anderson Valve Specialty Company, 1017 Fulton building, Pittsburg, Penn.

Fly-wheel Explosions

On August 12 two fly-wheels were wrecked at the plant of the Greenfield (Mass.) Electric Light and Power Company, causing a property loss of $2000. There was no independent safety-stop system at this plant.

On August 16 the breaking of the piston-rod of a 100-horse-power gasolene engine at the Saranac Lake (N. Y.) Lighting Power Company's plant caused the bursting of the two-ton fly-wheel. There was no independent safety-stop system.

On August 21 a fly-wheel in the No. 2 mill of the Whiting (Mass.) Paper Company burst and caused a thousand dollars worth of damage. The engine of No. 1 mill is equipped with the Monarch automatic safety system. No. 2 mill, where the accident occurred, was not so equipped.

On August 26 a 10-foot fly-wheel at the Iowa Gas and Electric Company's plant, Washington, Iowa, burst and caused damage amounting to $2000. There was no extraneous safety-stop system.

On August 30 a fly-wheel at the planing mill of the Mendhall Lumber and Manufacturing Company, Mendhall, Miss., was wrecked. The flying pieces damaged the plant considerably. No independent safety stop.

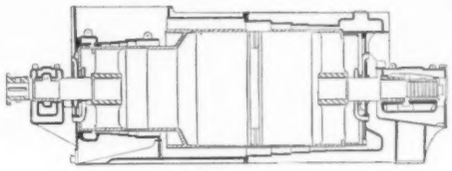
On September 3 a 20-foot fly-wheel was wrecked at the Jackson Lumber Company's plant at Florala, Ala., and caused damage estimated at $10,000, besides seriously injuring four men. The main belt broke. There was no safety-stop system.

On September 3 the fly-wheel in the engine room of the Lakota hotel, Chicago, went to pieces, presumably through the splitting of a dynamo belt. The property loss was considerable. Again, no safety-stop system.

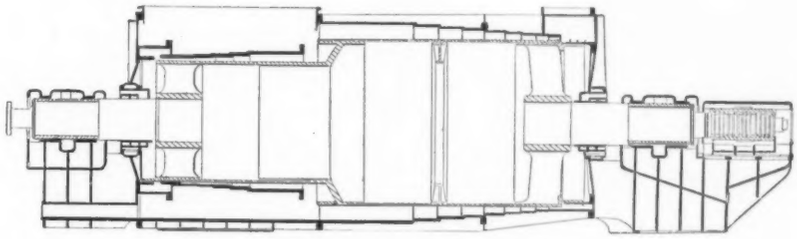
On September 7 a fly-wheel burst in E. Walton's sawmill at Byfield, Mass., killing a machinist. No safety stop.

Is It the Great Cunard Turbine?

This half-tone illustrated a recent paper by the inventor of the Parsons turbine. It is not told which of the large turbine steamers it belongs to, but the same paper contains the accompanying diagrams, and says: "In 1905 the Allan liners 'Virginian' and 'Victorian,' of 12,000 indicated horse-power, went on service between Liverpool and Canada; and in last December the 'Carmania,' of 30,000 tons displacement and 20,000 horse-power, commenced to ply between Liverpool and New York. The diagram shows her low-pressure turbine, which is 14 feet in diameter."

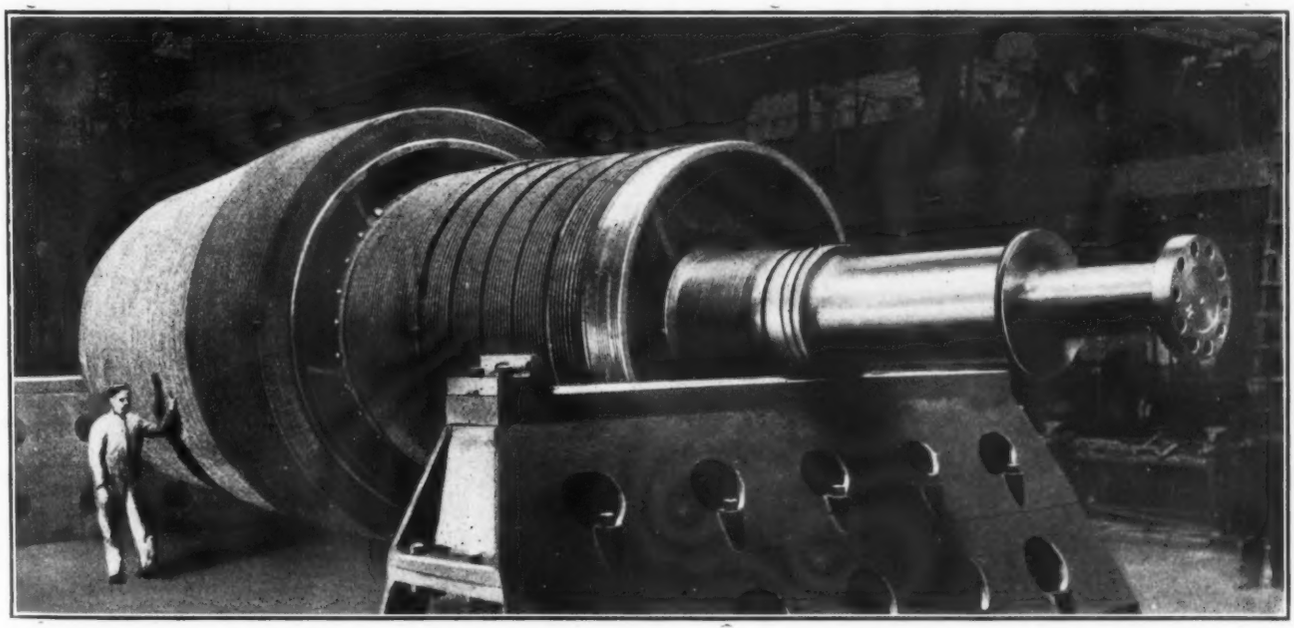


T.S.S. Virginian



T.S.S. Atlantic Liner 20,000 I.H.P.

DIAGRAMS OF TURBINES FOR TWO TRANSATLANTIC STEAMSHIPS



IS THIS THE ROTOR OF THE GREAT CUNARD TURBINE?

The N. A. S. E. Convention

The annual convention of the National Association of Stationary Engineers was held at Niagara Falls during the week commencing September 9. The first session was called to order on Tuesday forenoon by Charles A. Baker, chairman of the local committee, and after an invocation by Rev. A. S. Bacon, addresses of welcome were listened to from Judge Cromley, Hon. Peter A. Porter and John L. Harper, their remarks being responded to, respectively, by National President Theodore N. Kelsey, Vice-President Joseph F. Carney and John W. Lane, editor of the *National Engineer,* the organ of the association.

The report of the Committee on Credentials indicated the presence of 379 delegates entitled to seats, as against 365 last year.

The Committee on Standardization of Materials has collected a large amount of material, including the work of the American Society of Mechanical Engineers, the Master Steam and Hot Water Fitters' Association, the American Institute of Electrical Engineers, the New England Water Works Association, the Department of Commerce and Labor, Consular Reports, the Western Society of Engineers, and the Board of Trade of London, which it recommends printed and distributed among the membership. The committee calls attention to the lack of uniformity in indicator connections, and suggests that facility in the use and exchange of instruments would be furthered by a uniform connection, which it recommends should be ½-inch standard-pipe thread, the adoption of which will, in addition to the advantages of uniformity, allow of easy repairs in case of damage to threaded connections.

The License Committee reported that little has been accomplished in the way of obtaining legislation during the past year and very little effort appears to have been spent in this direction. Maine, New Jersey and Massachusetts appear to be the only States in which material progress has been made. Maine has enacted a law licensing engineers in public buildings; Jersey City, N. J., has enacted a local ordinance, and Massachusetts has repealed all acts relative to boiler inspection enacted prior to 1907, and enacted a new and better law.

The national secretary reported that there had been thirteen new associations organized during the year and four reinstated, while ten had returned their charters, making a net gain of seven associations. The present total membership is 19,465, a gain of 595 during the year. The receipts from the national organ were $7500, as against more than $10,000 the year before. The treasurer's report showed the finances of the association to be in good condition, with a comfortable balance in the treasury.

The Educational Committee announced that the first prize of $25 had been won by Lowell No. 17 of Massachusetts, the second prize of $20 by Moline No. 17 of Illinois, the third prize of $15 by Springfield No. 13 of Ohio, and the fourth prize of $5 by Evansville No. 7 of Indiana. Cambridge No. 30 of Massachusetts won honorable mention.

The committee on a home for indigent and aged members reported in favor of levying a per capita tax of $1 for this purpose. The recommendations of the committee will be submitted to the referendum vote of the subordinate associations next spring.

The annual memorial service took place at 11:30 o'clock on Thursday. National Secretary Raven read the names of the members who had died since the last national convention and remarks were made by a number of the delegates. The question of representation by State instead of local associations was laid upon the table, to be decided by the subordinate associations by a referendum vote.

The election of officers resulted in the choice of Joseph F. Carney, New York, president; Fred J. Fischer, Los Angeles, vice-president; F. W. Raven, Chicago, secretary; Samuel B. Forse, Pittsburg, treasurer; William P. Mead, Indianapolis, doorkeeper; W. J. Reynolds, Hoboken, conductor; John A. Kerley, Cincinnati, and Edward J. Lee, Albany, trustees of the *National Engineer,* the first being elected to fill the unexpired term of Charles H. Garlick, resigned. These officers were publicly installed by Past President James G. Beckerleg on Friday evening. After a spirited contest it was decided to meet at Denver, Colo., next year.

The natural attractions of Niagara Falls would have kept the visitors fully occupied with much more time than was left to them by the liberal program provided for their entertainment. Tuesday afternoon a visit was paid to the station of the Niagara Falls Power Company, and at 9:30 p.m. an informal dance was held at the Cataract House. On Wednesday the delegates and attendants upon the convention were taken by boat to Toronto, Ont., where they were the guests of the Canadian Association of Stationary Engineers. Returning, the boat reached Lewiston at 9 o'clock in the evening, and the return trip through the gorge was made by searchlight. On Thursday afternoon an automobile ride was provided for the ladies, and in the evening a vaudeville entertainment was given for all at the International theater. The social program closed with a grand ball at the Cataract House on Friday evening.

The Exhibitors' Association

The annual exposition of engineering supplies, etc., held by the National Exhibitors' Association, was established at the conservatory of the Natural Food Company, communication between which and the hotel where the convention was held and the delegates were quartered being maintained by free omnibuses. The exhibition was formally opened at 5 o'clock on Tuesday, when John A. Carson, president of the association, introduced Joseph F. Carney, vice-president of the national association, who reviewed the pleasant relations existing between the engineers and the commercial men and enlarged upon the necessity for their cooperation. The exposition was the largest and most successful in the history of the association. The commodious quarters afforded abundant space, even for this large display, which lent itself readily to tasteful and effective decoration. Notwithstanding the distance of the exhibition from the convention proper, most of the delegates spent a large portion of their time in looking over the exhibits, meeting the representatives of the commercial houses, and learning of new things available for use in their plants. The following companies and firms were represented:

Allis-Chalmers Co., Milwaukee.
American Boiler Economy Co., Philadelphia.
American Steam Gauge & Valve Mfg Co., Boston.
V. D. Anderson Co., Cleveland.
Arrow Boiler Compound Co., St. Louis.
Ashton Valve Co., Boston.
Ball & Wood Co., New York.
Bird-Archer Co., New York.
Chas. Bond Co., Philadelphia.
Cyrus Borgner Co., Philadelphia.
Buckeye Engine Co., Salem, O.
Buhne Metal Packing Co., New York.
Chandler & Taylor Co., Indianapolis.
Chapman Valve Mfg Co., Indian Orchard, Mass.
A. W. Chesterton & Co., Boston.
Cling-Surface Mfg Co., Buffalo.
Adam Cook's Sons, New York.
Carborundum Co., Niagara Falls.
Crandall Packing Co., Palmyra, N. Y.
Crane Co., Chicago.
Cyclone Grate Bar Co., Buffalo.
Dearborn Drug & Chemical Works, Chicago.
Detroit Lubricator Co., Detroit.
Diamond Power Specialty Co., Detroit.
Joseph Dixon Crucible Co., Jersey City.
Empire State Enginering Co., New York.
The Engineer, Chicago.
Engineering Journal of Canada, Toronto.
Engineer's Review, Cleveland.
Fairbanks Co., New York.
France Packing Co., Tacony, Penn.
Garlock Packing Co., Palmyra, N. Y.
Gibson Iron Works, Jersey City.
B. T. Goodrich Co., Akron, O.
Green, Tweed & Co., New York.
Hohman & Maurer Mfg Co., Rochester.
Hills, McCanna Co., Chicago.
Home Rubber Co., Trenton, N. J.
Hoppes Mfg Co., Springfield, O.
International Acheson Graphite Co., Niagara Falls.
International Correspondence Schools, Scranton, Penn.
Jenkins Bros., New York.
H. W. Johns-Manville Co., New York.
Kent Lubricating Co., Waukesha, Wis.
Keystone Lubricating Co., Philadelphia.
Kieley & Mueller, New York.
Geo. W. Knowlton Rubber Co., Boston.
Lagonda Mfg Co., Springfield, O.
Lake Erie Boiler Compound Co., Buffalo.
Leavitt Machine Co., Orange, Mass.
Liberty Mfg Co., Pittsburg.
Geo. W. Lord Co., Philadelphia.
Chas. T. Luce Co., Boston.
Lumen Bearing Co., Buffalo.
Lunkenheimer Co., Cincinnati.
Mason Regulator Co., Boston.
McCord & Co., Chicago.
James McCrea & Co., Chicago.
McLeod & Henry Co., Troy, N. Y.
Mechanical Rubber Co., Cleveland.
Morgan & Wright Co., Detroit.
National Engineer, Chicago.
New York Belting & Packing Co., New York.
Niagara Tachometer & Instrument Co., Niagara Falls.
Northern Specialty Co., Utica, N. Y.

THE NATIONAL EXHIBITORS' ASSOCIATION AT NIAGARA FALLS, SEPTEMBER 9-12, 1907

THE NATIONAL ASSOCIATION OF STATIONARY ENGINEERS AT NIAGARA FALLS, SEPTEMBER 9-12, 1907

Norwall Mfg Co., Chicago.
Oneida Steel Pulley Co., Oneida, N. Y.
Peerless Rubber Mfg Co., New York.
Pennsylvania Rubber Co., Jeannette, Penn.
Perfection Grate Co., Springfield, Mass.
Philadelphia Lubricating Mfg. Co., Philadelphia.
Pittsburg Gage & Supply Co., Pittsburg.
Potter Separator Co., Newburgh, N. Y.
Wm. Powell Co., Cincinnati.
POWER, New York.
Practical Engineer, Philadelphia.
Quaker City Rubber Co., Philadelphia.
Revere Rubber Co., Boston.
Ridgway Dynamo & Engine Co., Ridgway, Penn.
Jas. L. Robertson & Sons, New York.
John A. Roebling Sons Co., Trenton, N. J.
Jos. T. Ryerson & Sons, Chicago.
Sherwood Mfg Co., Buffalo.
Sims Co., Erie, Penn.
Southern Engineer, Atlanta, Ga.
State Mfg Co., Cleveland.
Steel Mill Packing Co., Detroit.
Strong, Carlisle & Hammond Co., Cleveland.
Strong Machinery & Supply Co., New York.
Trimont Mfg Co., Roxbury, Mass.
Under-Feed Stoker Co. of America, Chicago.
H. B. Underwood & Co., Philadelphia.
United States Graphite Co., Saginaw, Mich.
Walch & Wyeth, Chicago.

J. S. Walton & Co., Louisville, Ky.
Walworth Mfg Co., Boston.
Watson & McDaniel Co., Philadelphia.
Westinghouse Air Brake Co., Pittsburg.
Westinghouse Machine Co., Pittsburg.
Wickes Bros., Saginaw, Mich.
C. A. Wilcox Mfg Co., Chicago.
D. T. Williams Valve Co., Cincinnati.
Wright Mfg. Co., Detroit.

The annual meeting of the National Exhibitors' Association resulted in the choice of J. L. McGilvray, of the Peerless Rubber Manufacturing Company, president; C. K. Thomas, of the D. T. Williams Valve Company, vice-president; W. D. Purcell, of the Quaker City Rubber Company, secretary; G. D. B. Van Tassel, of the Westinghouse Machine Company, treasurer; Edward McCarthy, of the George W. Lord Company, John H. Foote, of the McLeod & Henry Company, and W. Schmidt, Jr., of the Lunkenheimer Company, members of the executive committee.

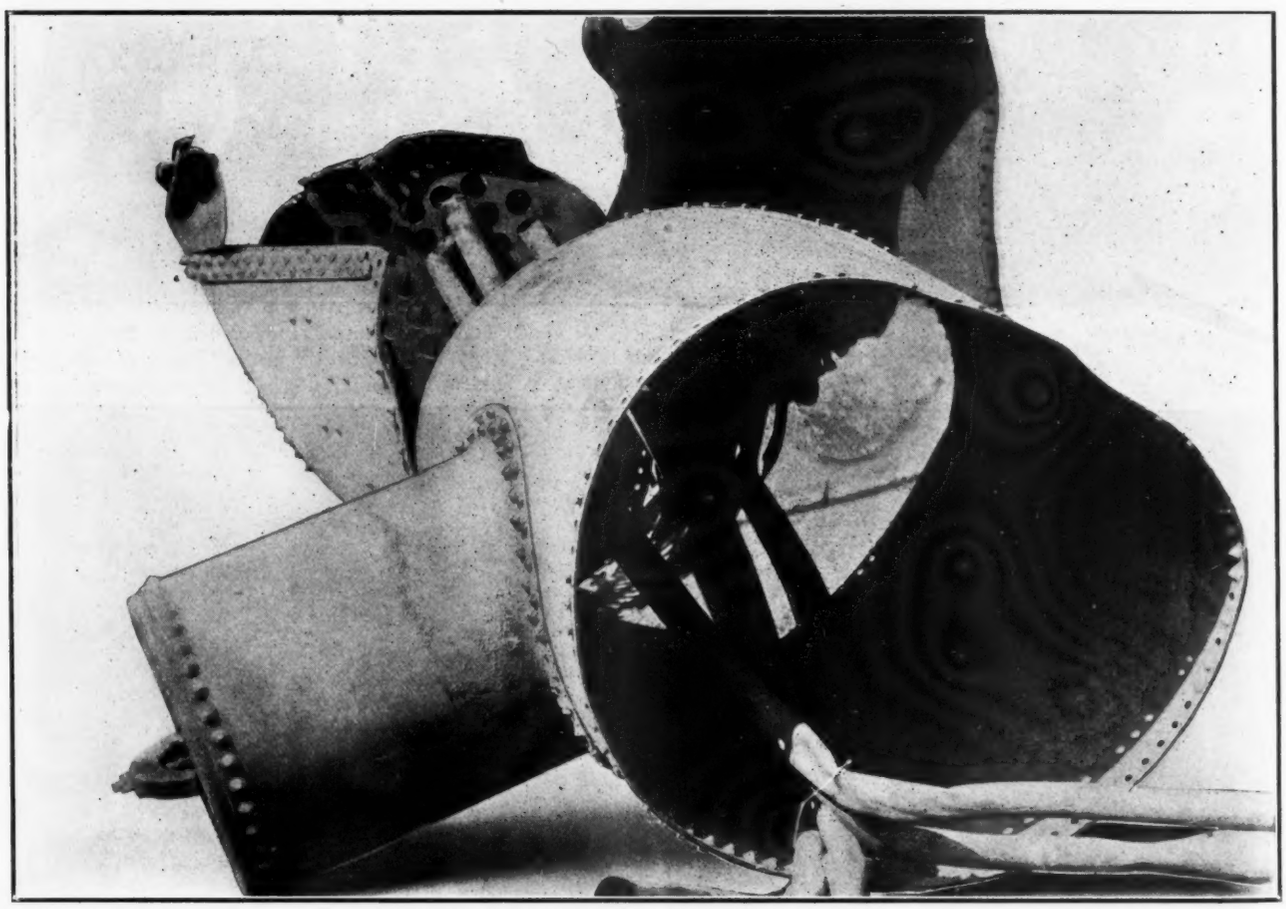
Boiler Explosion at Scranton

The accompanying photograph shows pretty plainly what happened to a horizontal tubular boiler in the Robbins & Spencer mill, at Scranton, Penn., as a result of an explosion which occurred on August 26 last.

It is clearly another case of lap-seam with internal cracks extending to within one-sixteenth of an inch of the surface, but undiscoverable by inspection, as they were covered by the lap. The longitudinal joint of the middle ring of the boiler, which was left intact by the explosion, was cut open and the plates found to be badly cracked inside.

It is said that the plates showed evidence of low water, and that this has been assigned as the immediate cause of the failure, but the violence of the explosion, which wrecked the setting and projected portions of the shell to a distance of 200 feet, was such that there must have been a considerable body of heated water present when the rupture occurred.

The boiler was 14 feet long, 60 inches in diameter, built of 11/32-inch plate in three rings with double-riveted lap-joints longitudinally; and with 13/16-inch rivet holes pitched 3⅛ inches. It was built a dozen or more years ago and allowed 80 pounds to the square inch. It was thoroughly inspected on May 12, and subjected to a less searching internal examination on August 12, without revealing any defects.



EXPLODED BOILER AT THE ROBBINS AND SPENCER MILL, SCRANTON, PENN.

American Peat Association

After many years of agitation the plan for the organization of those interested in the development of American peat and swamp land has matured so far that the dates October 23-26 have been selected for a meeting for this purpose, to be held at the Jamestown Exposition, where the United States Geological Survey has established a fuel-testing plant at which peat and peat products will be on exhibition. A peat exhibit will also be made in the Mines and Metallurgy building, at which it is expected to show raw peat in such a manner as to exhibit differences in origin, structure and amount of decomposition, peat in the form of hand and machine bricks and briquets, coal and charcoal, to-

gether with analyses and comparative tests with other forms of fuel. Peat adapted for use as fertilizer, and litter; peat paper and peat fabrics will also be exhibited as will illustrations of peat plants at home and abroad, and examples of peat literature. A number of papers will be read upon peat and related subjects, and the meeting will conclude with an excursion to "Dismal Swamp." The formal opening of the Fuel and Alcohol building on October 25 will add to the interest of the occasion. Particulars may be obtained by addressing Julius Bordollo, Kingsbridge, New York City.

Resignation of Professor Goss

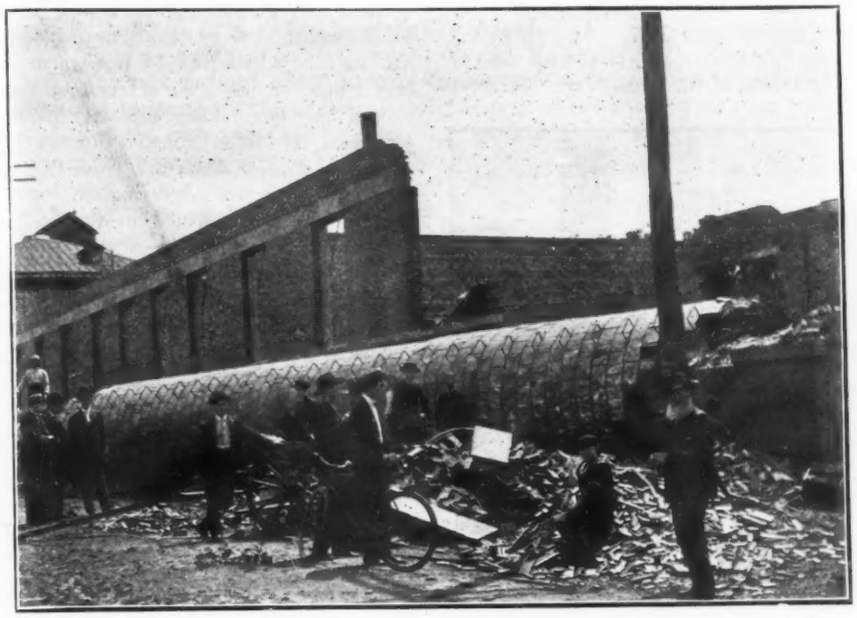
Dr. W. F. M. Goss, dean of the school of engineering at Purdue University, has resigned to accept the deanship of the engineering schools of the University of Illinois. Professor Goss, a graduate of the Massachusetts Institute of Technology, has been connected with Purdue since 1879, the time he began the organization of his department.

The members and guests who attended the Indianapolis meeting will remember Professor Goss as the host at the very interesting and enjoyable session held at Purdue the last day of the convention.

An evening course in industrial engineering, intended to give manufacturers, contractors and their employees a working knowledge of engineering principles which enter into the construction and operation of their plants, was begun on September 26 by New York University, under the direction of Dean Joseph F. Johnson, at the school of commerce, accounts and finance in New York city.

Chimney Blown Down by Tornado

On the morning of August 11 last an unusually severe tornado visited La Crosse, Wis., and among other damage occasioned by it a reinforced-tile chimney, 150 feet high and 6 inches inside diameter, which had been completed but five days, was blown down. The chimney was erected for the Michaels Brewing Company by the Atlas Construction Company, builder of the Weiderholt system of walls and chimneys.



BASE AND LOWER SECTION OF CHIMNEY WRECKED BY TORNADO

The tile consists of two curved plates forming inside and outside surfaces of the chimney, these plates being about ten inches long, nine inches high and three-quarters of an inch thick and connected at their centers by a ¾-inch web. These are laid up similar to the radial-brick chimney and the spaces around the webs and between the plates are filled with cement mortar, the mortar being of a proportion of one part cement to three parts of sand. In this mortar were inserted horizontal and vertical bars. This construction makes a reinforced shell about nine inches thick. The mortar filling is practically continuous from top to bottom and the construction of the tiles holds them in place. The vertical bars in the section immediately above grade consisted of 1-inch square twisted bars and 1-inch square corrugated bars spaced about 9 inches center to center, making a total of about 27 bars in the section.

The same number of bars runs clear to the top of the chimney, but the sectional area of the bars is decreased about half-

RUINS OF UPPER PART OF CHIMNEY WRECKED BY TORNADO

way up. The horizontal bars were ½-inch square corrugated bars, spaced about 9 inches center to center in the lower part of the chimney, and about 18 inches center to center in the upper part of the chimney. The top of the connecting web between the two tile plates of each tile has an opening left for the passage of the horizontal bars.

It is stated that during the storm the wind reached a velocity of 60 miles an hour. The accompanying photographs show the resultant damage clearly.

ANOTHER VIEW OF LOWER PART OF CHIMNEY WRECKED BY TORNADO

Large Copper Exhaust Pipes

As an example of heavy copper-pipe work the accompanying illustration is particularly interesting, as the pipes shown are of very unusual weight and sizes. They are the main exhaust pipes of the Curtis turbine steamship "Creole," and were made at the copper shop of the Fore River Shipbuilding Company, builder of the vessel, at Quincy, Mass. Each of these pipes weighs 2500 pounds, is 42 inches in diameter, inside measurement, and the metal 5/16 of an inch in thickness. Each was made from sheet copper in four pieces and the skill used in brazing these pieces is clearly shown in the smoothness and shapeliness of the pipes. The pipe is nearly, if not quite, the largest-size copper pipe made in this country for marine purposes. The Fore River company has the contract for building one of the proposed 20,000-ton battleships for the United States Navy.

Flow of Steam in Pipes

In the September number, in the letter on "Formulas for the Flow of Steam in Pipes," by William J. Crowell, Jr., a typographical error ocurred in the fifth line, first column, page 627. As published it reads, "T_2 will be always greater than the temperature of the steam," etc. It should read, "T_2 will be always somewhat greater than the temperature of the surrounding air."

A patent has been granted to Charles M. Hose, of Indianapolis, Ind., for a valve, the seat of which is threaded, the closure being made by a similarly threaded plug screwing into the seat. An annular disk at the top of the threads forms a stop and seats upon the flat top of the partition.

Rifled Pipe Line for Conveying Oil

The contract has been let by the Southern Pacific Company for the building of a rifled oil-pipe line 256 miles long from oil properties in Kern county in the southern part of California to tide-water on San Francisco bay. An interesting feature of the line is the character of the pipe used, its "rifled" construction being a somewhat radical departure from that of lines now in use for conveying oil. Spiral indentations accomplished in the rolling of the pipe constitute the rifling.

An exhaustive series of experiments has demonstrated that after a small per cent. of water has been added to the oil, and the necessary pressure applied, the whole will develop a whirling motion, and the water, being the heavier, will seek the outside of the pipe, enveloping the oil in a thin film or shell of water, greatly reducing the friction and allowing the core of oil to glide through the pipe readily.

Throughout the length of 256 miles of pipe there will be twenty-three pumping stations, the equipment of each station being in duplicate, so that in the event of a breakage of any part of the machinery of one pump the other many immediately be put into service.

With the size of the pipe, which is 8 inches, and the high pressure and improved facilities, a rapid transmission of the oil has been shown to be possible, and it is estimated that at least 23,000 barrels of fuel oil can be delivered every twenty-four hours.

The United States Civil Service Commission announces an examination on October 23 for the position of second-class or assistant steam engineer for the Custom House and Post Office building at Salt Lake City, Utah, and similar vacancies as they may occur in the custodian service in any city in the United States. Salary, $900 per annum; age limit, 18 to 55 years. Applicants should apply to United States Civil Service Commission, Washington, D. C., for application form 1052.

THE 42-INCH COPPER EXHAUST PIPES OF THE TURBINES OF THE U. S. S. "CREOLE"

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Weight of Ash-pit Door

The following question and answer were contributed by a POWER subscriber.

In Fig. 1 is shown a cast-iron ash-pit door, which is inclined about 5 degrees from the vertical; that is, it has a slope of about one inch per foot, so that its weight tends to keep it closed. The door is hinged at one side, but has no other fastening. The air pressure in the ash-pit, furnished by the blower, amounts to 3⅓ pounds against the inner surface of the door, tending to open it. The weight of the casting forming the door is about 8 pounds. What additional weight must be applied to keep the door closed?

This problem may be solved either graphically or by the application of trigonometry. The graphical method is shown in Fig. 2. Draw two lines making an angle of 50 degrees; the line *A-B* should have the same slope as the door, and the line *A-C* should be vertical. At any convenient location, draw a line *d-e* perpendicular to the line *A-B*, and on this lay off a distance *a* to any convenient scale equal to 3⅓ pounds, or the total air pressure normal to the surface of the door. Draw the line *f-g* through the point *a* parallel to *A-B*, and where it intersects *A-C* at *r*, draw the line *r-s* perpendicular to *A-B*. Then the length of the line *A-r* to the same scale as the line *a* will be the the total weight of the door. This is found by measurement to be approximately 40 pounds.

The formula for the trigonometric method is as follows:

$$Ar = a \div \sin 5^\circ = 3\tfrac{1}{3} \div 0.08333 = 40.$$

An extra allowance should be made to insure the door being kept tightly closed. Hence, at least 40 pounds additional weight should be added to the casting, making its weight about 48 or 50 pounds. One method of doing this would be to increase the thickness of the body of the door from one-half inch to an amount that would make the total weight of the casting about 50 pounds, as follows:

$$50 \div (4\tfrac{3}{4} \times 9\tfrac{3}{4} \times 0.26) = 4 \textit{ inches},$$

approximately. The friction caused by the weight of the door on its hinges will aid in keeping the door closed.

Hight to which a Pump Will Lift Water

How can I figure the hight to which an ordinary steam pump will deliver water? The only pressure against the pump is that due to the weight of the lifted water.

G. W. S.

Ignoring the work required to force the water through the pump connections, the hight in feet, measured from the level of the supply to the level of the discharge outlet, is given by the formula

$$\frac{2.3 \times D^2 \times p \times e}{d^2} = hight.$$

In this formula,

D = Diameter of steam piston in inches,
d = Diameter of water piston in inches,
p = Mean effective steam pressure per square inch,
e = Efficiency of the pump, over all.

An approximation which will serve in most instances for estimating can be made and the formula somewhat simplified by assuming an efficiency of 70 per cent. for the pump. Then the formula becomes

$$\frac{1.6 \times D^2 \times p}{d^2} = hight.$$

Water Required by Surface and Jet Condensers

Which type requires the greater quantity of cooling water per pound of steam under identical conditions, the surface or the jet condenser? P. W. W.

If the surface condenser be provided with sufficient heating surface to bring the temperature of the cooling water up to that of the condensed steam and if the temperature of the latter is the same in both types, the quantity of cooling water will be the same. If the surface condenser does not heat the water to the temperature of the condensed steam, all other conditions being the same, it will require more cooling water than the jet condenser. In practice this is usually the case.

Heating Surface of Return-tubular Boilers

How is the effective surface of an ordinary return-tubular or other fire-tube boiler computed? A. A. S.

The heating surface is considered to be the sum of the inner surfaces of all tubes, two-thirds of the external shell surface and two-thirds of the net surfaces of both tube-sheets. For the ordinary return-tubular boiler this may be expressed in formula shape as follows:

$$\frac{DL + \frac{D}{2} + 1.5\,d\,n\,(L - \frac{1}{3})}{68.75} = S.$$

Here,

D = Diameter of boiler shell,
L = Length of boiler shell,
d = Mean diameter of boiler tubes,
n = Number of tubes,
S = Square feet of heating surface.

All measurements are in inches except the result.

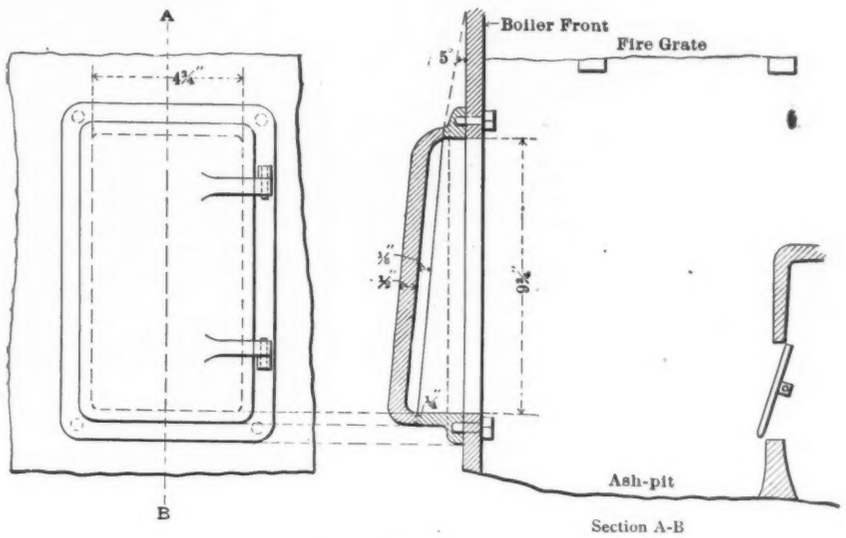


FIG. 1

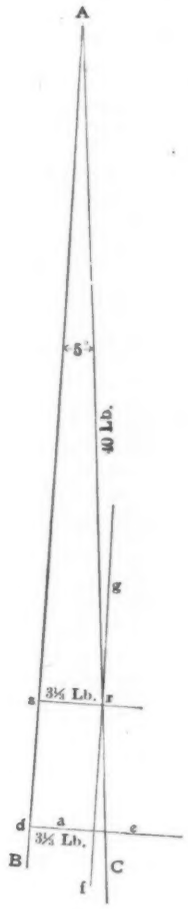


FIG. 2

New Catalogs

Warren Webster Company, Camden, N. J. Circular. Grease and oil trap. Illustrated.

Wilpaco Packing Company, 31 Nassau street, New York. Circulars. Hydraulic packing.

James Bonar & Company, Pittsburg, Penn. Catalog. Oil filter. Illustrated, 32 pages, 6x9 inches.

H. W. Johns-Manville Company, 100 William street, New York. Circular. How to Clean a Boiler.

United Lubricator Company, Detroit, Mich. Catalog. Lubricators. Illustrated, 32 pages, 5½x7½ inches.

F. E. Keyes & Son, 20 Broad street, New York. Folder. Advance feed water purifiers. Illustrated.

McLeod & Henry Co., Troy, N. Y. Booklet. "Steel Mixture" boiler appliances. Illustrated, 4x5 inches.

Mason Regulator Company, Boston, Mass. Catalog. Regulating devices. Illustrated, 80 pages, 4x6 inches.

D. D. Flanner Boiler Company, Toledo, Ohio. Catalog. Park water-tube boiler. Illustrated, 16 pages.

The Lunkenheimer Company, Cincinnati, O. Booklet. Blow-off valves. Illustrated, 24 pages, 3½x6 inches.

Kent Lubricating Company, Waukesha, Wis. Catalog. Greases, boiler compound, etc. Illustrated, 3½x8 inches.

The Bigelow Company, New Haven, Conn. Catalog. Bigelow-Hornsby water tube boiler. Illustrated, 9½x12 inches.

Vulcan Soot Cleaner Company, of Pittsburg, DuBois, Penn. Circular. Vulcan horizontal tube cleaner. Illustrated.

American Huhn Metallic Packing Company, 1876 Broadway, New York. Catalog. Metallic Packing. 3½x6 inches.

Tacony Iron Co., Land Title Building, Philadelphia, Pa. Catalog. Tacony turbine pumps. Illustrated, 6x9 inches.

Boston Gear Works, Norfolk Downs, Mass. Catalog E. Gears, chains, bearings, etc. Illustrated, 88 pages, 3½x6 inches.

The L. S. Starrett Company, Athol, Mass. Catalog No. 18. Fine mechanical tools. Illustrated, 232 pages, 5x7½ inches.

Joseph Dixon Crucible Company, Jersey City, N. J. Booklet. Graphite brushes. Illustrated, 12 pages, 3½x6½ inches.

C. Lee Cook Manufacturing Company, Louisville, Ky. Catalog. Metallic packing. Illustrated, 32 pages, 3½x6½ inches.

The Hawley Down Draft Furnace Company, Chicago, Ill. Catalog. Hawley down draft furnace. Illustrated, 7x10 inches.

Gould & Eberhardt, Newark, N. J. Catalog. "High Duty" shapers and attachments. Illustrated, 50 pages, 6x9 inches.

Power Specialty Company, 111 Broadway, New York. Catalog. Foster patent superheater. Illustrated, 44 pages, 6x9 inches.

Fred M. Prescott Steam Pump Company, Milwaukee, Wis. Catalog. Pumping machinery. Illustrated, 146 pages, 6x9 inches.

Lagonda Manufacturing Company, Springfield, Ohio. Pamphlet. Automatic boiler cut-off valve. Illustrated, 12 pages, 6x9 inches.

The D. T. Williams Valve Company, Cincinnati, Ohio. Booklet. Cookson steam traps. Illustrated, 16 pages, 3½x5½ inches.

Pittsburgh Feed Water Heater Company, Pittsburg, Penn. Catalog. Feed water heater and purifier. Illustrated, 64 pages, 6x9 inches.

Cutler-Hammer Manufacturing Company, Milwaukee, Wis. Booklet. Electric crane controllers. Illustrated, 24 pages, 3½x8 inches.

The Kennedy Valve Manufacturing Company, 57 Beekman street, New York. Catalog. Valves, hydrants, etc. Illustrated, 132 pages, 5x9 inches.

Atlas Construction Company, 912 Victoria building, St. Louis, Mo. Catalog. Chimneys (Wiederholt System). Illustrated, 24 pages, 4x9 inches.

Buffalo Steam Pump Company, Buffalo, N. Y. Catalog. Steam, power, centrifugal and turbine pumps. Illustrated, 132 pages, 6x9 inches.

The Standard Steam Specialty Company, 542-544 West Broadway, New York. Catalog. "Utility" steam specialties. Illustrated, 5x10 inches.

Hohmann & Maurer Manufacturing Company, Rochester, N. Y. Catalog No. 50. Gas works thermometers. Illustrated, 48 pages, 7x10½ inches.

The Keystone Chemical Manufacturing Company, Philadelphia, Pa. Catalog. Pressure filters and water softening plants. Illustrated, 26 pages, 6x9 inches.

Westinghouse Lamp Company, 512-534 West Twenty-Third street, New York. Catalog. Incandescent lamps. Illustrated, 36 pages, 5x8 inches.

Weber Gas Engine Company, Kansas City, Mo. Catalog No. 22. Producer gas engine and suction gas producer. Illustrated, 18 pages, 8x11 inches.

H. W. Johns-Manville Company, 100 William street, New York. Circulars. "J-M" electric heater and "Electrobestos" arc deflectors. Illustrated.

The Hershey Machine and Foundry Company, Manheim, Penn. Booklet. Baum steam and oil separators. Illustrated, 14 pages, 3½x7 inches.

Atlas Engine Works, Indianapolis, Ind. Bulletin No. 134. General illustrations and specifications of engines and boilers. 23 pages, 8x10½ inches.

R. D. Wood & Co., Philadelphia, Penn. Booklet. Centrifugal pumps for water works and high pressure fire service. Illustrated, 36 pages, 6x9 inches.

Bird-Archer Company, 90 West street, New York. Pamphlet. Ten Questions With Their Answers—A Book for Steam Boiler Users. 16 pages, 6x9 inches.

O'Oller Engineering Company, Philadelphia, Penn. Bulletin, Series T, No. 8. Centrifugal and turbine pumps. Illustrated, 8 pages, 6½x10 inches.

General Electric Company, Schenectady, N. Y. Pamphlet. Electric heating and cooking devices for marine use. Illustrated, 8 pages, 8x10½ inches.

Thomas Andrews Manufacturing Company, Rockaway, N. J. Catalog. "Rapid" turbine tube cleaner and hose coupling. Illustrated, 12 pages, 3½x7 inches.

Ashcroft Manufacturing Company, 85 Liberty street, New York. Catalog. Gages, indicators, pipe stocks and dies, etc. Illustrated, 135 pages, 6x9 inches.

Standard Force Feed Lubricator Company, 38-42 North Water street, Rochester, N. Y. Pamphlet. Force feed lubricators. Illustrated, 8 pages, 3½x6 inches.

Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburg, Penn. Catalog No. 8. Steam and water specialties. Illustrated, 56 pages, 5½x8 inches.

Mason Regulator Company, Boston, Mass. Catalog. Automatic regulating devices for steam, electric and power pumps. Illustrated. 55 pages, 6x9 inches.

New Equipment

G. Henshaw & Sons, Cincinnati, Ohio, will erect a power plant.

The City of Bennettsville, S. C., will install a water-works system.

The Ola (Ark.) Lumber Company contemplates installing an electric light plant.

The Stephens-Adamson Company, Aurora, Ill., is erecting a new brick boiler room.

The Paris (Ky.) Electric Light Company contemplates increasing the capacity of its plant.

The Robinson-McGill Carriage Company, Nashville, Tenn., will erect a new $10,000 plant.

The City of Lindsay (I. I.) has voted $25,000 bonds for the construction of water works.

Shaw Bros., Fort Worth, Texas, will establish an ice plant of 100 tons daily capacity.

The Escanaba (Mich.) Electric Power and Pulp Company is making plans to erect a new plant.

T. W. Carroll, Charleston, S. C., is putting up extensive additions to his ice-making and cold-storage plant.

The Salem (Mass.) Electric Light Company is building a $20,000 addition to its power plant.

The Fresno (Cal.) Home Light and Power Company, recently incorporated will erect a $280,000 power plant.

The Consumers' Ice Company, Chester, Penn., is preparing to rebuild its plant recently destroyed by fire.

The Nashville (Tenn.) Gas Company will erect an additional plant to meet the increased demand for gas.

The Fort Smith (Ark.) Light and Traction Company is making arrangements to increase the capacity of its plant.

The Pacific Gas and Electric Company, Santa Rosa, Cal., has awarded contract for the erection of a sub-station.

A new $100,000 factory building will be erected for the Theobald & Oppenheimer Company, Philadelphia, Penn.

The plant of the Hartford City (Ind.) Artificial Ice Company has been destroyed by fire, causing a loss of $20,000.

The City of Camden, Ark., is considering establishing municipal water works, at an estimated cost of about $80,000.

The city council of Aurora, Minn., is reported to be considering the question of installing an electric lighting system.

The Martinsburg (W. Va.) Gas Company will change from coal gas to water gas system and make other improvements to its plant.

The Americus (Ga.) Light and Railway Company, newly organized, has started the erection of the new $250,000 electric power plant.

It is reported that the Madison (Wis.) Gas and Electric Company intends expending about $75,000 for new buildings and machinery.

The Decatur Light, Power and Fuel Company contemplates spending about $70,000 on improvements to its plant in New Decatur, Ala.

The Weleetka (I. T.) Light and Power Company contemplates building addition and making improvements to water works system. D. F. Campbell is manager.

The Little Rock (Ark.) and Pine Bluff Traction Company is preparing to build an electric power plant for its 50-mile railway. Offices are at 501 Main St., Little Rock.

The Apex (N. C.) Water Company has been incorporated to furnish water-power and lights. Capital $25,000. C. P. Sellars, J. Beale Johnson, P. J. Olive, incorporators.

The Wetumpka (Ala.) Power Company has been organized to build and equip a power and lighting plant. M. Hohenburg, H. Hohenburg, F. W. Lull and others, incorporators.

The Standard Safety Boiler Company, Fort Wayne, Ind., has been incorporated; capital $50,000. Directors, Samuel K. Gregg, Charles E. Colerick, and Walter M. Gregg.

The city of Brownsville, Texas, will vote on the issuance of $70,000 bonds for water works and electric light plant. W. P. Bullock, Kansas City, Mo., is engineer in charge.

The La Crosse (Wis.) Water Power Company is building a 16,000-horse-power plant on the Black river at Hatfield, Wis. Nearly $1,500,000 will be spent on the first installation.

The Consolidated Railway and Light Company, Youngstown, Ohio, will spend thousands of dollars in extensive improvements at its plant. A new fuel conveyer will be erected.

The Seminole (Texas) Water Works has been organized to drill artesian well and install a plant for the distribution of the water obtained. Capital, $10,000. H. C. Whitfield, manager.

Plans have been completed for the Russell Sage Mechanical and Electrical Laboratory to be erected at the Rensselaer Polytechnic Institute, Troy, N. Y. This will cost about $250,000.

The British Columbia Electric Railway Company is planning to make extensive additions to its property in New Westminster. Over $100,000 will be spent on new buildings.

The Dixie Lighting Company, Wilson, N. C., has been chartered with $12,000 capital to manufacture lighting and heating appliances. J. R. Hardy, J. R. Joyner, and others, incorporators.

The Standard Electric Light, Heat and Power Company, Avoca, Penn., is planning to increase the capacity of its plant. A 300-kilowatt engine type alternator will probably be installed.

An ordinance has been passed by the city council of Bryan, Ohio, to issue bonds for the purpose of buying equipment for the municipal electric-lighting plant and waterworks plant.

The Westford (Mass.) Water Company has been organized to furnish water to several towns and construction work will begin at once. Edmund M. Blake, 8 Beacon street, Boston, is president.

The Mobile (Ala.) Light and Railroad Company is having plans prepared for improvements for doubling the capacity of its power station. About $100,000 will be expended on equipment.

The Board of Public Improvements of St. Louis, Mo., has approved plans for a municipal lighting and heating plant for the Quarantine Hospital building and machinery to cost about $10,000.

The Anaconda Copper Mining Company (foundry department), Anaconda, Mont., would like to receive catalogs from manufacturers of machinery tools and power equipments of all kinds.

The Government is peparing to install at the Presidio General hospital at San Francisco, one 75-kilowatt direct-current generator, one 5-ton ice machine and two 100- or 125-horse-power boilers.

The Williamston (N. C.) Light and Power Company has been incorporated to generate and transmit electric power, etc. Capital, $50,000. Incorporators, John D. Biggs, Asa F. Crawford and S. J. Everett.

The Argenta (Ark.) Ice and Cold Storage Company, recently organized, will establish an ice and cold storage plant at a cost of nearly $50,000. Dr. H. L. White is president, U. S. Goodwin, manager.

The Atlantic Refining Company, C. Wm. Rice, chief engineer, 3144 Passyunk avenue, Philadelphia, Penn., would like to receive catalogs of engines, motors, pumps and all power plant equipment and supplies.

The Lowell (Ind.) Light and Power Company has been incorporated to construct and equip light and power plants in Lowell and other cities in Indiana. C. Wiley, E. L. Shank and J. M. Jones are diretcors.

The Morrison's Cove Electric Light and Power Company, Martinsburg, Pa., has filed articles of incorporation, with a capital stock of $50,000. J. W. Wagner, of Barbara, Pa., J. W. Suther, of Indiana, Pa., and others are incorporators.

The power plant of the Claremont (N. H.) Railway and Lighting Company, will be extended. A 1000 horse-power engine and a 600 kilowatt generator will be installed, and a 11,000-volt transmission line, 17 miles long, will be constructed.

Business Items

The Handy Trap Company has removed its offices to 207 South Second street, Philadelphia, Penn.

The L. J. Wing Manufacturing Company, of New York, recently installed turbine blowers for mechanical draft and disk fans, ventilating, etc., in 29 large industrial plants.

The Garlock Packing Company has its new four-story brick factory and store at 670 Howard street, San Francisco, in full operation and is employing forty men in that branch.

The Sight Feed Oil Pump Company, Milwaukee, Wis., has opened a New York office in the West Street building, 90 West street. Wm. Martin, manager for the New York territory, is in charge.

The Utah Copper Company has installed in the Garfield plant, Garfield, Utah, two Northern cranes, one of 15-tons 3-motor electric type, with 40-foot span, and one of 6 tons capacity, hand type.

The Trill Indicator Company, Corry, Penn., reports an exceptionally heavy July and August business, the orders for its instruments equaling the very satisfactory business experienced during the winter and spring.

The Chorry Cotton Mills, of Florence, Ala., recently placed a contract with the Allis-Chalmers Company, of Milwaukee, covering a 500-kilowatt Allis-Chalmers steam turbine and alternator unit, together with a turbo jet condenser and an engine-driven exciter.

The increasing demand for Powell steam-engineering specialties makes an enlargement of the plant of the Wm. Powell Company, of Cincinnati, a necessity. Plans are being prepared to erect buildings on ground 37x200 feet recently acquired, and to increase the power plant by 200 horse-power.

The damage to property caused by the bursting of a fly-wheel at the plant of the Youngstown (O.) Iron and Steel Roofing Company, mention of which was made in the September number, amounted to $6200, which loss has been settled by the Fidelity and Casualty Company, of New York.

The Parker Boiler Company, of Philadelphia, is erecting the fourth order received from the J. B. Stetson Company, also of Philadelphia. When this order, which calls for two boilers of 750 horse-power capacity each, is completed, the Parker boilers in the Stetson plant will aggregate 7000 horse-power.

Adam Cook's Sons, 313 West street, New York City, in their exhibit at the N. A. S. E. convention showed the various consistencies of Albany grease, also various-styled grease cups adapted to all classes of bearings, showing especially the Albany spindle cup. Demonstrations were made, showing that Albany grease can be used in any style of grease cup on the market.

The Locke Regulator Company, Salem, Mass., reports that there were 46 fly-wheel explosions during the first six months of this year and nearly 20 since then, with a property damage of approximately more than one million dollars. These fly-wheel explosions have given an impetus to the Locke Company's engine-stop business and it reports recent sales of 29 Locke engine-stops.

The American Steel and Wire Company, after having in operation a 12,500-horse-power We-Fu-Go water-softening and purifying system for six months at the Donora works, has just placed an order with Wm. B. Scaife & Sons Company, of Pittsburg, for a 25,000-horse-power We-Fu-Go system, consisting of eight large treating and settling tanks and eight mechanical gravity filters, for the Newburgh steel works at Cleveland, Ohio.

The Pittsburgh Gage and Supply Company, Pittsburg, Penn., recently installed White Star continuous-oiling systems in nine engine rooms. It is stated that the great saving in lubricating oil, requiring but one handling by human means (from barrel to system), its constant use, being cleaned by the White Star filter after passing through the bearings, and thence used over and over again until actually worn out, renders the use of an oiling system a necessity in every up-to-date power plant.

The Riverside Engine Company, Oil City, Penn., builder of the Riverside heavy-duty gas engine and gas-driven air and gas compressors, is strengthening its sales department by establishing a number of sales agencies. L. B. Lent, M. E., formerly of the Wile Power Gas Company, will have charge of the New York office, at 26 Cortlandt street. The Pittsburg office, at 710 Empire building, will be in charge of the N. C. Davison Company. The W. E. Austin Company, with headquarters in the Candler building, Atlanta, Ga., is looking after this line in the southern territory. Arrangements will shortly be made for sales agencies covering the western territory.

Just what can happen when a steam main bursts or a fitting on the line breaks, or one boiler of a battery gives way, is vividly told in a newly issued pamphlet describing the Lagonda automatic boiler cut-off valve. The pamphlet also explains the dangers from ammonia explosions and the way in which the cut-off valve may be used to stop the flow before enough of the ammonia gets out to do any harm. A number of interesting tests are given to show the certainty with which this type of automatic valve does the work in case of accident. The valve is illustrated in detail and its action explained. This pamphlet may be had free by writing to the Lagonda Manufacturing Company, Springfield, Ohio.

A very disastrous fire visited the new Hunt street factory of the D. T. Williams Valve Company, Cincinnati, and the building was completely destroyed. The company had just moved the lubricating department into this building prior to the fire and it is the only department to suffer, to the extent of tools and machinery, the patterns remaining intact at the Broadway plant. The company is installing a new lubricating department at

410 and 412 East Eighth street, which will be the temporary quarters until the old factory is rebuilt. Castings and tools are being made with all possible despatch and deliveries on lubricating devices will begin about October 15. This general announcement of the fire is necessary, owing to the fact that false reports have circulated among the trade regarding the extent of the losses and the ability to make deliveries.

Following the tests recently made on the 1000-kilowatt Allis-Chalmers turbo-alternator, in operation for some months past at the power house of the Kokomo, Marion & Western Traction Company, this company placed an order with the Allis-Chalmers Company for a duplicate of the turbine unit installed, comprising a 1000-kilowatt turbine driving a 1000-kilowatt alternator, with turbo jet-condensing system complete. The unit is wound for 30 cycles, 2-phase, 2300 volts. This unit, like the one already in service, will operate normally with steam pressure of 140 pounds per square inch gage pressure at the turbine throttle, dry saturated, and a vacuum of 28 inches of mercury, referred to a 30-inch barometer at the exhaust nozzle. The unit is calculated to carry an overload of 50 per cent. when operating under the above steam conditions and at 100 per cent. power factor. The second unit will be placed beside the first one in the power house at Kokomo, Ind., and will furnish power for lighting and railway service.

For the benefit of those interested in the lubrication of elevator and pump plungers the work being done in the building of the Merchants Warehouse Company, Philadelphia, is interesting. There are sixteen big plunger elevators, supplied with hydraulic power at 140 pounds pressure by three 14x11 and 20x15 Worthington tandem compound pumps. That is, there are three such pumps there ready for service, but only one of them at a time is needed to do the work. This is because throughout the entire hydraulic system friction has been reduced to such an extremely low point that one pump is enabled to accomplish the work which seemingly would require at least two. After a good many more or less troublesome experiences with various greases Keystone grease, No. 3 density, was finally adopted, and has ever since given the best of satisfaction. The method of applying is to place 25 pounds at a time in the packing box of each plunger. This amount lasts about two months, and keeps not only the elevator plungers but the whole system of pumps, pipes and valves lubricated and preserved from corrosion.

The C. & G. Cooper Company, of Mt. Vernon, Ohio, has just completed the installation of a large fly-wheel for the Youngstown Iron and Steel Roofing Company, Youngstown, Ohio, in record time. The wheel was built to replace one which burst on Aug. 5. The old wheel had been in service a great many years and, with the engine, was built in Providence. The Youngstown company gave the order for the new wheel on August 5, with the understanding that it was to be shipped in twenty-six days. It is 24 feet 8 inches in diameter and weighs 90,000 pounds. It was designed, cast, machined and shipped complete from the works of the Cooper company on August 31, or in eighteen working days. This anticipated the promised delivery about five days. It was delivered to the roofing company, Sunday, September 1, and was erected and running by Tuesday, September 3. The new wheel is of the square-rim type, made in halves, held together at the rim by double-headed, countersunk tees of fagoted iron, and at the hub by four 4-inch bolts and also double-headed tees. The arms are oval, ten in number. The joints of the wheel are fitted with 3-inch tool-steel dowels, which serve the double purpose of insuring a true joint and resisting centrifugal strains.

Help Wanted

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

WANTED IMMEDIATELY—A stationary engineer for cement plant in middle west; 2400 h.p. steam engines and 1200 kw. alternating generators. Apply at once, Box 278, POWER.

WANTED—A man with experience in the sale of engines and engine specialties, preferably one that has had shop experience and understands how to indicate engines, set valves, etc.; for further information address Box F, Hudson, N. Y.

FIRST-CLASS representative wanted by reputable house to handle flour mill and grain elevator machinery; must be experienced with knowledge of trade, to make headquarters in New York; good opportunity for right man; commission and expenses. Reply to Box 285, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

DESIGNER, MECHANICAL, wants work; experienced in electro-mechanical design; good references. Box 280, POWER.

POSITION WANTED as chief engineer by a first-class engineer, hold a first-class Massachusetts license, am also a good machinist Address Box 286, POWER.

SUPERINTENDENT or master mechanic; technical and practical, ability in designs of special machinery and tools for interchangeable manufacture. Box 282, POWER.

DRAFTSMAN, university graduate, married; 28 years old, with 5 years' experience in steam-turbines, boilers, governors and water turbines, wishes position. Box 283, POWER.

MECHANICAL ENGINEER and draftsman, technical education, 15 years' experience in Corliss and piston valve steam engines; references of first-class factories, moderate salary, wants position. Box 284, POWER.

MECHANICAL SUPERINTENDENT for corporation; technical graduate; manufacturing experience from the foundry to the drafting room; thoroughly experienced in construction work; age 28; good habits. Box 277, POWER.

EXPERIENCED, electrical, mechanical graduate, desires position as chief engineer, electric light and power plant; am also first-class air compressor man; six years experience direct and alternating current, competent and reliable; married and employed at present, but desire a change; best references. "N. E. H.," Box 279, POWER.

Miscellaneous

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

ACTIVE, RELIABLE party, with office in Liberty street, New York, desires to take agency for articles in the power or engineering line. Box 281, POWER.

IF YOU DESIRE to learn the latest improvement in steam boilers, correspond with the Detroit Water Tube Boiler Co. See their advertisement on page 169.

ENGINES AND BOILERS, ⅛ to 2 h.p. engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make free examination and report if patent can be had, and exact cost.

WE FURNISH engines for low pressure and high pressure, slow speed and high speed, adapted for all purposes. Send for circular and prices. Greenfield Steam Engine Wks., Harrison, N. J.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

For Sale

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

ONE 6x10x10 jet condenser made by Snow Steam Pump Co., used about two years. Address the Water Board, J. Lewis Grant, Supt., Auburn, N. Y.

FOR SALE—Cyclopedia of electricity; five volumes, three-quarters red morocco, leather binding; books are in fine condition; used but short time; cost $19; will sell for $9. Address "R. S. M.," POWER.

FOR SALE—A slightly used engineering library. Steam, electrical, mechanical. Twelve volumes bound in three-quarters red morocco leather. Cost new $60. Will sell for $18. Address "R. L. N.," POWER.

FOR SALE—Cyclopedia of engineering; steam, electrical, mechanical; bound in three-quarters morocco; four volumes; cost new $19; are in fine condition; will sell for $9. Address "M. B. T.," POWER.

FOR SALE—500 kw. d.c. railway generator, belt driven, three bearing, e.m.f. 550, six pole, 320 r.p.m., serial number 149054, manufactured by the Westinghouse Electric and Manufacturing Company; machine in good condition. For further information, address Detroit United Railway, Detroit, Mich.

FOR SALE—Three (3) 200 kw. 125-250 volt d.c. 3-wire Westinghouse generators direct connected to 16-28-18 vertical compound Ball engines, 200 r.p.m., 150 lbs. steam pressure. All above units are in service and can be seen running; one can be delivered Sept. 1, 1907. Address Wm. G. Boyle, superintendent Oliver Power Plant, H. W. Oliver Estate, Pittsburg, Pa.

FOR SALE—Two 25 kw. direct current 110 volt Crocker-Wheeler generators direct connected to De Laval steam turbines suitable for 125 to 150 pounds steam pressure condensing or non condensing; also one 2200 gallon centrifugal pump direct connected to De Laval steam turbine; this is new machinery. Address The National Cash Register Company, Dayton, Ohio.

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The Transformation of Heat into Work

The Conversion of Various Forms of Energy Graphically Described. A Simple Introduction to the Temperature-entropy Diagram

BY PROF. SIDNEY A. REEVE

In the lecture on "Physical Properties of Saturated Steam," published in the September number, it was shown how falling water may perform work in either

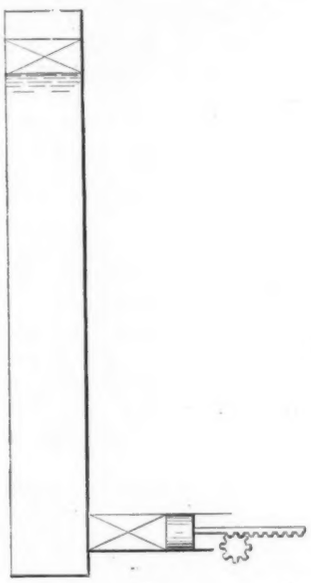


FIG. 1

of two ways, by its pressure or by its momentum. One of the illustrations in that lecture (Fig. 1 herewith) shows a reservoir having a piston at the bottom apparently about one-fourth the area of the stand-pipe. Let us suppose that the stand-pipe contains 400 pounds of water. Then the pressure on the piston would be one-fourth that on the bottom of the pipe, or 100 pounds. Let the piston be permitted to move out by the volume of one pound of water, then 400 pounds have fallen by one four-hundredth of the hight from the water level to the pump cylinder. The work done is plainly that of one pound of water falling the entire distance. The piston would move out one-hundredth of the same distance, or "head," of water. Its work would be one-hundredth of 100 pounds times the entire distance, as before.

In the same way it can be shown that in the accompanying Fig. 2 the water issuing in a horizontal jet would strike the wheel with the same velocity and energy as if each pound of water fell freely through the air for the entire hight and struck the wheel tangentially at its right-hand side. Imagine each pound of water to be permitted to act in this way separately. A single pound of water is placed in the top of the reservoir. Then a pound's worth of work is drawn off at

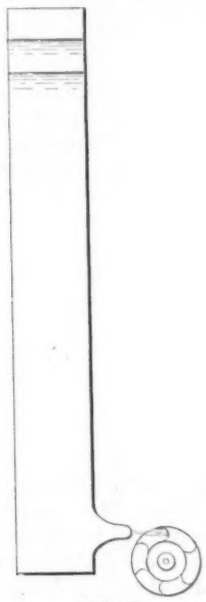


FIG. 2

the bottom. Then the pound of waste water is thrown away. Then a fresh pound of water must be placed in the top of the reservoir, if the supply of power is to be continuous, and so on.

This general process can be usefully

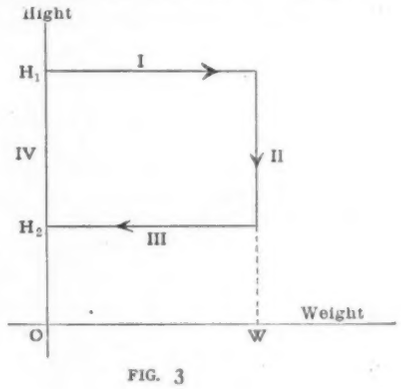


FIG. 3

represented by a diagram such as Fig. 3, wherein the hight of fall of the water is represented vertically and the weight of the water is shown horizontally. Thus, if any weight of water W be taken into the system at the level H_1, be then permitted to fall, doing work, to a lower level, H_2, and be there discharged, the work done will be

$$Work = W\ (H_1 - H_2).$$

It is to be noticed here that the third process is just as important as is the first. A water-wheel will no more work properly with a choked tail-race than it will with a poor water supply. It should also be noted that the pound of waste water must somehow be put back into the reservoir, some time or other, if things are to work continuously. The sun performs for us a similar task by evaporating sea-water into clouds and raining it on the hill-tops again.

Fig. 4 shows the form in which this work appears upon the piston. The preliminary filling of the reservoir, before the machine started, produces the pressure P_1 on the piston. This process is shown by the line *IV*. When the pound of water is admitted the piston moves out by the distance *D*. This is the process *I*. Then the supply is cut off and the exhaust is opened. The pressure falls, resulting in the process *II*. The piston is then returned against the smaller resistance P_2, making the process *III*.

The net work done is $(P_1 - P_2)\ D$.

The Cycle

A four-faced series of processes such as this is called a *cycle*. It always consists, first, in biting off, so to speak, a piece from the general stock of supplies. The

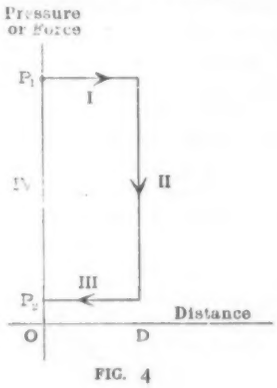


FIG. 4

size of this "bite" is measured by the width of the diagram.

Secondly, this "bite" of stuff and energy is permitted to fall down what is called the *intensity* of its energy. In mill-pond energy this intensity is vertical *hight*, measured in feet. In the energy of gen-

eral fluid-pressure lines, such as hydraulic systems or compressed-air conduits, or in piston-rod pushes and the like, wherever the energy acts purely mechanically, this intensity of energy is the *force* or *pressure* available.

Thirdly, the "bite" of energy, having given up its intensity and lost its availability for further work, has become waste and is thrown away or exhausted.

Fourthly, the machine is made ready to repeat the process.

One very important form of cycle is

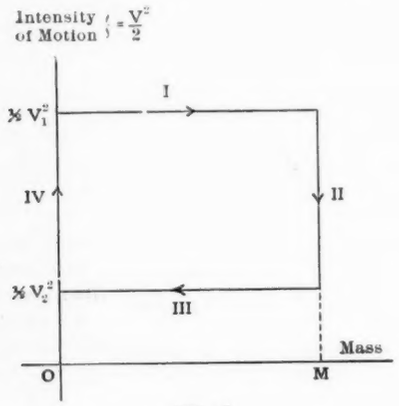


FIG. 5

that of the energy of motion, as in the hydraulic jet striking the wheel. This is illustrated in Fig. 5, showing the action in the wheel of Fig. 2. In the case of motion-energy the intensity of the motion is properly measured, not by its velocity, but by one-half the square of the velocity, stated in feet per second. Why this is so we do not know. The vertical dimensions of Fig. 5, therefore, exhibit the velocity of motion, squared and halved.

The size of the "bite" involved in motion-energy is measured by the *mass* which is in motion. The mass of a body is found by dividing its weight at sea level by 32.16.

When the water approaches the wheel of Fig. 2. it possesses the intensity of motion, $\frac{1}{2}V_1^2$. A unit mass of water enters the wheel with this motion. This is the process *I* of Fig. 5. Then the mass strikes the curved and moving vanes of the wheel. Its motion is lost; *not* by impact, producing heat, but by a gradual and oblique diversion, whereby work is done. This is the process *II*. Then the waste water is discharged, forming the process *III*, which obviously cannot take place if the velocity has been reduced to zero. Finally, a succeeding "bite" of water gets up velocity, ready to get into the wheel and strike the next vane, which is the process *IV* indicated on the diagram.

Direct and Reversed Cycles

Cycles such as those drawn are called *direct*. They always *develop* and give out power. They are illustrated by diagrams with arrow-heads making the circuit in a clockwise direction. Suppose the arrow-heads of Fig 5 to be reversed. It will then illustrate the action of the *nozzle* of the turbine, whereas before it showed the action of the *wheel*. For the nozzle or guide-blade of a turbine is an energy-transforming machine of no mean importance, especially in these days of steam turbines.

The nozzle receives one pound of water, say, at a low velocity (Process *III* reversed). The converging form of the nozzle raises the velocity (Process *II* reversed). The water is discharged from the nozzle at high velocity (Process *I* reversed). Another "bite" of water is then taken into the nozzle. Such a cycle is called a *reversed* cycle. It always *absorbs* power. It is illustrated with diagrams in which the arrows complete the circuit in *counter-clockwise* direction. Every clockwise cycle must develop a counter-clockwise cycle, and *vice versa*. Thus, the first cycle in our chain was that of Fig. 3, a direct one, or the cycle of the penstock. This cycle developed in the nozzle the reversed cycle of Fig. 5 reversed. This developed again in the vanes of the wheel a new direct cycle, that of Fig. 5 as it is drawn. The power issuing from the water-wheel again develops new reversed cycles, which it is not our business to follow here, and they again develop further direct cycles.

The series of cycles acts like a chain of clocks which might be imagined so arranged that each one, in running down, wound up its next neighbor. The second clock, being set when wound up, would pass on the energy to the third clock, and so on. In each clock would occur first a reversed and then a direct cycle.

In each cycle the work developed or absorbed is measured by the hight times the width of the diagram, or its area. Hence the area of each diagram in the chain of cycles must be the same, except for losses of energy incurred as we pass from cycle to cycle. But the shape or proportions are unlimited. A wide, flat, direct cycle may produce a tall, narrow, indirect cycle, or *vice versa*.

Efficiency

Fig. 5 is the first of the diagrams which will make plain what is meant by the efficiency of a cycle. In that cycle, whatever intensity of motion the water possesses as it leaves the wheel is a direct source of loss. The energy put into the water in the process *IV*, and taken into the wheel in the process *I*, is measured by the area beneath that line down to the zero axis, or $\frac{1}{2} M V_1^2$. The energy taken up by the wheel is $\frac{1}{2} M (V_1^2 - V_2^2)$. Therefore the efficiency of transformation is

$$F = \frac{V_1^2 - V_2^2}{V_1^2} = \frac{I_1 - I_2}{I_1},$$

wherein *I* is the intensity of motion, or $\frac{V^2}{2}$. This efficiency in an actual water-wheel is always less than unity; for we cannot get the water away from the wheel and at the same time have its velocity zero.

The same is true of a water-piston. There must always be some head, or intensity of hight, left in the water, or it would not leave the cylinder when the exhaust is opened. Indeed, this "remnant" of intensity is always, in actuality, the entire fall from the machine to the sea level, which is considerable; but it is not usual to take this into consideration.

Suppose, now, that we consider the diagram of an actual machine, instead of a theoretic one. Such a diagram would be Fig. 6. It can be read for either hight-energy, pressure-energy or motion-energy, for the axes are labeled only for *intensity* of energy and for *extent* of energy, as we call the size of the "bite," respectively.

The energy is supplied at the upper level I_1 and can be discharged to the lower level I_2. But some loss of intensity is involved in getting the working substance into the machine. If it be a water-wheel, some head is lost between the mill-pond and the wheel, or some intensity of motion is lost in friction. The wheel receives the energy not along the line *A B*, but at a lower level of intensity *a b*.

Or perhaps, as might be the case in Fig. 1, the reservoir has to be filled before pressure can be accumulated, requiring, say, one-sixth of each "bite" of water to get up pressure. This would be shown by the line *d a*.

We should get this same sort of a line in the nozzle-diagram, if the nozzle were made of rubber, so that it had to be stretched, as each pound of water reached it, before full velocity could be attained.

Again, if the piston leaked, or the

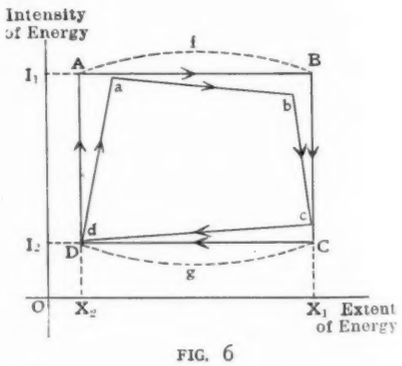


FIG. 6

water-wheel vane had a hole in it, some of the "bite" would get down to exhaust conditions before the work were all done. This would be shown by the line *b c*, showing a "leak." Finally, the machine might not exhaust freely. The water would be driven out while still having more motion or more pressure than is theoretically necessary. Such action would be shown by the line *c d*.

In all these cases there is a *free fall* of the energy "down intensity." As the "bite" *A B* enters the machine it falls

freely, without doing work, from the level of supply I_1 to the various levels of *d a b c*. As it leaves it falls freely from the levels of *c d* to the level of exhaust *C D*. All such free fall constitutes loss of efficiency. It is plain that the actual cycle can *never exceed* the theoretic rectangle. Water supplied at the *A B* level would never enter the machine at the levels of *A f B*, for instance. It will not flow "up intensity" from *A B* to *A f B*. Nor could any machine exhaust from the levels of *C g D* up into a tail-race at the *C D* level.

Consider now an actual *reversed* cycle, as in Fig. 7. Such a cycle must *always exceed* its theoretic rectangle, just as the actual direct cycle must always lie inside. The energy *D C* will not enter the machine except at some lower levels, such as those of *D g C*. It will not leave except by some higher levels, such as *B f A*. Such an action is as inefficient as would be that of a hod-carrier who, when told to carry bricks from the street to the fourth floor of a building, should first go down into the cellar with his hod, drop the bricks into the hod from the street level, then carry it to the fifth floor and dump the bricks back to the fourth floor. Yet the hod-carrier must perforce do some such thing as that, at least to the extent of a few feet, if he is to get his bricks into and out of his hod automatically. The bricks will get into his hod of themselves if he lets them slide down a chute; and will get out again in the same way. All of our pumps, grain elevators and refrigerating machines work in this way, going below the level of supply to be charged and discharging at a higher level than the waste-carrier. And all of these machines work upon reversed cycles, absorbing power in order to pump energy "up intensity." In the refrigerating machine it is the energy which we are after. We wish the beef cooled. We care little what carries the heat "up temperature" out of the beef. In the grain elevator it is the grain we are after; we care little about the energy in it. In the pump it may be either the substance or the energy which is wanted. In all cases the principle of operation is the same.

It is now plain that a *direct* cycle has a *better* efficiency the *bigger* it is; yet it may never exceed its rectangle. The *reversed* cycle, on the other hand, is the more efficient the *smaller* it is; yet it may never be smaller than its rectangle. Plainly, therefore, the rectangle is the limiting form, of maximum efficiency for either direct or reversed cycles, *between any given pair of limits in intensity.*

With this fact firmly fixed, and *remembering* that the efficiency of any rectangular cycle is given by the expression $\frac{I_1 - I_2}{I_1}$, we are equipped to understand better how heat performs work.

The Steam-engine Cycle

The first fact to be understood about heat is that temperature is its factor of intensity. Heat always tries to get "down temperature" just as persistently as water tries to get down hill. It will flow from a hot body to a cold whenever it gets a chance. If we put a machine of the right sort, such as a steam engine, between a hot body such as a steam boiler and a cold body such as a condenser, the heat will do work as it flows "down temperature," from boiler to condenser, just as the water-wheel set between the head-race and tail-race will do work.

If temperature be the intensity of heat-energy, what measures its *extent?*

In the forms of energy with which we are more familiar we can measure directly all the factors, such as hight, weight, pressure, distance, velocity, mass, etc. By multiplying the proper ones together in pairs we get a measure and an understanding of their energy.

With heat, however, we have to reverse this rule. We can measure heat-energy directly, in B.t.u. We can measure temperature directly. When we impart a

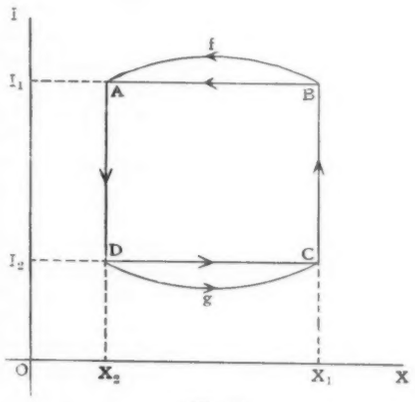


FIG. 7

heat unit to a substance we may divide the heat imparted by the absolute temperature at which it is imparted. The result corresponds exactly to the dividing of hight-weight energy by hight, giving weight as the result, or of dividing motion-energy by intensity of motion, giving mass. In the case of heat this dividend is the *extent* of the heat-energy involved. It is the "heft" of the heat, being to the heat just what the mass of the hammer-head is to the blacksmith's blow. It is, indeed, the true *mass* of the heat. It embodies the portions of the mass of each molecule which are separated from the body of the molecule to take part in the heat-energy. When the body radiates its heat these portions recombine with the body of the molecule. This is just as a lump of water, or a cannon ball, or a railroad train temporarily separated from identity with the earth in order to contain energy, recombines with the earth when the energy is gone.

This subdivision or comminution of the mass of the molecule in heat-motion is called *entropy.* It is of the same importance in heat action that mass is in mechanics. Neither of these quantities can we perceive directly; yet we cannot compute nor understand any natural action without them.

In thinking of these matters we must not imagine a molecule as a solid sphere, or anything like that. A molecule is an exceedingly complex body. It is more like a complete solar system, or a nebula, than like a solid spherical moon. It has a central nucleus, just as our solar system has in its sun. It has innumerable outlying portions which revolve about the central nucleus—probably a much larger number than the few thousand visible bodies which compose our solar system. As bodies grow hotter increasing portions of the molecule's mass separate from the central nucleus to take part in the outer orbits of the motion which we call heat. If we could ever get any substance into the condition described as a "perfect gas" the central nucleus would be all gone, all split up finely into freely moving fragments. If we could ever get any substance absolutely cold and solid, at 461 degrees below zero Fahrenheit, the molecule would be completely consolidated into its solid nucleus. But neither of these states has ever been attained in matter; and we now know, from mathematical considerations, that they never can be attained.

It is the orbital portion of the molecule only which takes part in heat-motion.

The Entropy Diagram

Let us now start with one pound of water at 32 degrees Fahrenheit, to heat it and to draw on paper a picture of what we have done. Fig. 8 will be the picture, with *A* for the starting point.

The first thermal unit added is given at the temperature of $461 + 32 = 493$ degrees Fahrenheit absolute. The entropy involved is therefore $\frac{1}{493} = 0.0020285$. For the next unit the water is one degree warmer and the entropy is $\frac{1}{494} = 0.0020245$, and so on. Each of these additions of heat, therefore, may be exhibited as a tall, narrow rectangle running up from the axis of absolute zero of temperature. Each represents a fresh "bite" of mass taken off the molecule and set into orbital motion; and as the intensity of motion becomes greater the additional mass required to embody a unit of energy naturally becomes smaller and smaller. That is to say, the entropy per degree rise in temperature becomes less and less.

Remember that the water itself has nothing to do with absolute zero. Nevertheless, our picture will not be true geometrically unless each little rectangle rests on the zero axis of temperature.

The entropy values found by the simple arithmetic given above are not quite correct. Correct values will be found in Peabody's or Reeve's "Steam Tables."

By the time the point *a* is reached the temperature has become 212 degrees Fahrenheit, let us suppose. The entropy will then be 0.3126. But let the water be

in a boiler under the pressure which has been used in the other illustrations, 120 pounds absolute per square inch. More heat can then be added and more entropy developed until the temperature has become 341 degrees Fahrenheit and the entropy 0.4906.

Now exists equilibrium between the molecules trying to expand and the boiler shell holding them in. As long as the shell is as hot as the steam it can abstract no *heat* from the steam. As long as it stands still it can abstract no *work*. So the steam perforce stays in the condition *B*.

Now suppose that the boiler shell should give way. What happens? No *heat* is abstracted, as before, for there is no time for that. But *work* is now suddenly abstracted. The molecules are bombarding the shell. If a boy bombards the end of a freight car with base balls, so long as the car stays still no work can be done by the bombardment; and the balls, if perfectly elastic, come back to the boy as "hot" as he sends them in. But if the car be moving away from the boy the bombardment contributes work to it; and the balls now return to the boy with their velocity diminished by twice the speed of the car.

It is just so when the boiler shell retreats before the bombarding of the steam molecules. The accelerating retreat of the shell permits it to take up work from the molecules. It does so by robbing them of the *intensity* of their motion.

But there is nothing about the process to tend to consolidate either the base balls or the molecules. Their number and their mass remain the same. Therefore the heat-energy, in exploding the boiler, *gives up its intensity of energy at constant mass or entropy.* It drops down the plumb-line *B C*. When it reaches *C* it has to stop because the momentum of the molecules then just equals atmospheric pressure (as the steam tables tell us), and they can contribute no more energy to the boiler shell.

How much energy has the hot water developed by its explosion (for nothing has been said yet about steam)? Plainly, the difference between its stocks of heat before and after exploding.

Areas measure heats. The water's original fund of heat was measured by the area beneath *A B*, down to the zero axis. Its fund after explosion is measured by the area beneath *A a C*. The difference is the triangle *a B C*.

The area of this last can be computed most easily by subtracting from the heat put into the water (from feed-water temperature), or the area *b a B c*, the rectangle *b a C c*. The hight of this rectangle is 673 degrees. Its width is 0.4906 — 0.3126 = 0.1780. The area is therefore 673 × 0.178 = 119.8 B.t.u.

The heat put in between *a* and *B* is, by steam tables, 131 B.t.u. The difference between 131 and 119.8, which has gone into work by bombarding and propelling the retreating boiler-plates, bricks, etc., is 11.2 B.t.u. = 8714 foot-pounds per pound of hot water released.

Few engineers can perform this simple computation. One of the best boiler text-books published in this country computes this result *just eleven times too great.*

Suppose, however, that the boiler did not explode. Suppose that when the pound of water reached the condition *B*, it began to boil into steam. As it did so it pushed back the steam above it; the pressure was transmitted through a pipe to an engine cylinder, and there pushed out the piston, doing work. Why is not this just like the boiler explosion?

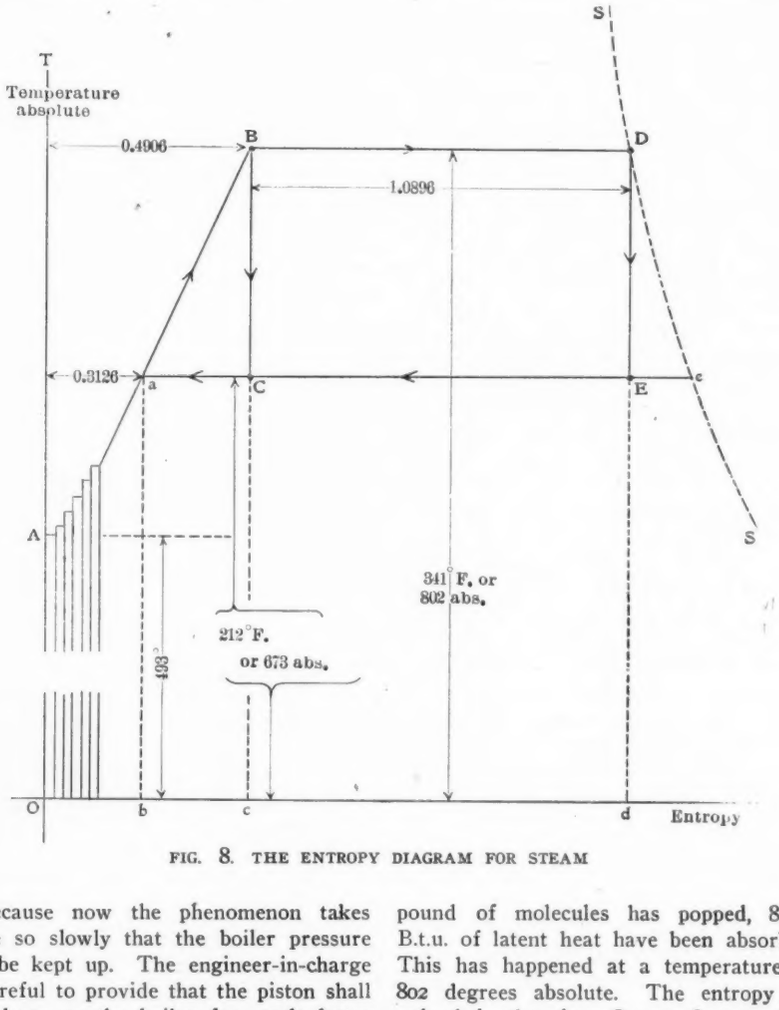


FIG. 8. THE ENTROPY DIAGRAM FOR STEAM

Because now the phenomenon takes place so slowly that the boiler pressure can be kept up. The engineer-in-charge is careful to provide that the piston shall not draw on the boiler for work faster than the boiler can supply steam and at the same time maintain pressures constant; whereas in a boiler explosion the flying pieces take up all the work they can get, at the expense of the steam pressures—which many engineers permit to drop scandalously during boiler explosions.

So in the present case, instead of the boiler's exploding, the water molecules explode. They pop into steam, one after another, as fast as each gets hot enough, quite like corn in a popper, each one bursting suddenly into more than two hundred times its original volume. Only, whereas the popcorn, once popped, is popcorn forever, the molecules of steam may be turned back into water at any time, by sufficient cold and pressure. They may be condensed and re-popped into steam any number of times, without wearing out.

Each molecule pops into steam at *constant temperature* and at *constant pressure;* only the volume is increased. The stock of heat is also very much increased, although the temperature does not rise. Each molecule takes up a large stock of latent heat. The entropy, or the orbital mass of the molecule, is greatly increased during explosion into steam, as might be expected. By the time the entire pound of molecules has popped, 873.7 B.t.u. of latent heat have been absorbed. This has happened at a temperature of 802 degrees absolute. The entropy involved is therefore 873.7 ÷ 802 = 1.0896. These entropy values for steam can be found only in Reeve's "Steam Tables."

On the diagram, the latent heat is measured by the rectangle *c B D d* and the entropy by *B D*. The steam is now dry saturated, at the condition *D*.

If the same construction should be performed for a number of different boiler pressures we should get a number of points like *D*, which would together form the *saturation curve S S*. It is particularly to be noticed, however, that *the saturation curve does not represent a process.* No single process is known by which saturated steam of one pressure can ever

be altered into saturated steam of any other pressure.

The pound of water being now all steam, and having pushed a pound of steam into the cylinder as the piston moves out, let us cut off this last pound from its fellows, by closing the admission valve, and let it work on the piston by its own elasticity. What happens?

Now we have the boiler explosion again. That is to say, we have the abstraction of *work* without the abstraction of *heat;* for we suppose the cylinder walls to be non-conducting. Only now, instead of its being a pound of hot water exploding, it is a pound of equally hot dry steam.

The energy drops "down intensity," as before, down the plumb-line $D\,E$. When it gets to E it can no longer push the piston effectively, because the opposing atmospheric pressure now just balances it. So the pound of steam has become waste, and we throw it away or exhaust it.

How much work has it done? The difference between the heat it originally had and what it still has at E. What it had at D was the area $O\,A\,B\,D\,d$, or, by steam tables, 1185.5 B.t.u. What it has at E is the area $O\,A\,a\,E\,d$. The difference is the area $a\,B\,D\,E$, or that of the cycle, as might be expected. The heat put in was that at D minus what it had at a, or $1185.5 - 180.8 = 1004.7$ B.t.u. The heat to be abstracted from the condition E in order to get the steam back to condition a is the rectangle $b\,a\,E\,d$, or the hight 673 times the width $a\,E$. The latter is $0.4906 - 0.3126 + 1.0896 = 1.2676$, and $673 \times 1.2676 = 852.8$ B.t.u., or the area $b\,a\,E\,d$. The area $a\,B\,D\,E = b\,a\,B\,D\,d - b\,a\,E\,d = 1004.7 - 852.8 = 151.9$ B.t.u. $= 118{,}178$ foot-pounds.

This is the utmost work possibly to be had from a steam engine using saturated steam of 105.3 pounds gage pressure and exhausting into the atmosphere, *even if of ideally perfect construction.*

One horse-power-hour amounts to 1,980,000 foot-pounds, or 2545 B.t.u. Such an engine as the above should therefore consume $2545 \div 151.9 = 16.754$ pounds of steam per horse-power-hour. If it actually consumes, say, 28 pounds, it is doing only $16.754 \div 28 \times 100 = 59.8$ per cent. of what it ideally could do. This last figure alone is the measure of the skill with which the designer has done his work. It is called the *cylinder efficiency,* or the *diagram factor.*

Hero of Alexandria, B. C. 130, made a reaction wheel; William Gilmore first suggested the compound steam turbine in 1837; Matthew Heath first enunciated the principle of the diverging conical jet in 1838; James Pilbrow in 1842 used cupped buckets, and suggested a sinuous treatment of the steam; Robert Wilson developed the compound steam turbine to a considerable extent in 1848.—Hon. C. A. Parsons.

Chief Points of Difference between the Gas Engine and the Steam Engine

By William H. Booth

In all matters pertaining to mechanical engineering there is always a tendency to follow a certain beaten track which has been traced out by a vehicle similar to the one we happen to be in. But this does not always lead to good results. As between the gas engine and its forerunner the steam engine, there are great points of difference, though in general appearance there may be nothing much to choose between them and their principle of action may be much alike. Let one point alone be considered in this article. Let there be taken the shape of the indicator diagram of the steam engine. Let its general form be considered and the reasons for that form, and for the angle of any particular line and the physical facts which may influence such details, or the mechanical facts which render them necessary. We have all observed that the diagram of the gas engine is taken from it with a similar instrument and that the form of the diagram is almost identical with that of the steam-engine diagram. In fact, we may learn that the gas-engine diagram has been tinkered at until it has resembled in shape, as closely as it could be made to do, the indicator diagram from the steam engine.

In order to fix our ideas let a brief résumé be made of the thermal and mechanical conditions of each of the heat engines, the steam and the gas engine. In the former case the working cylinder is, to use the word of Watt, maintained as hot as the steam which enters it. If it be not so maintained then it will proceed to attain the same temperature as nearly as it can do, by abstracting heat from the working fluid, from the steam within it, and much of this will be condensed as a result. Were we to admit steam somewhat later in the stroke no benefit would accrue in practice, and as we shall see later, in ordinary cases the mechanical action of the machine would be spoiled and turning moments rendered irregular. There might be set up shock and noise.

In a steam engine it is not usual to compress the residual steam in the cylinder up to the pressure in the boiler. When the piston reaches the end of the stroke and it becomes necessary to move it outward once more, it cannot be started moving except by a considerable force, such force being proportioned to the velocity, or rather to the square of the velocity, and only to be got out of either the fly-wheel through the medium of the crank-pin and other parts, or from steam pressure admitted behind the piston. If the fly-wheel be the moving power the forces in the connecting-rod are reversed and any slackness of parts is demonstrated by noise or knock.

With steam as the starting agent the lost motion of the working parts is gradually made good by compression and the steam is admitted directly upon the dead center and starts the piston on its forward path with no further shock, for all lost motion is taken up and pressure is continuously in one direction, so that reversal cannot occur.

Salient Features of the Steam-engine Diagram

Thus it is that the steam-engine diagram has been evolved to its present form. The salient features are a vertical steam-admission line, a horizontal line of sustained pressure up to the point of cut-off, an expansion curve, exhaust opening and a sustained exhaust line, followed by a more or less extended curve of compression ending in the first-named vertical line of steam admission. We might, of course, rely on a full compression of the residual steam to boiler pressure to start the piston in movement, and calculate on a late steam admission, if we believed it to be an economical advantage to do this. But the expansion of the compressed steam would follow the compression curve or even fall below it. It would be very steep and the pressure to urge forward the piston would quickly fall below a sufficient degree, and again there would be a mechanical knock. So that even if it were desirable from a heat-engine point of view to admit steam late, quite an appreciable time after the crank had passed the dead center, it would not be mechanically desirable.

This I. state, fully aware of the fact that in the early days of higher pressures the old beam engines of Lancashire would not admit of steam admission dead upon the center in all cases. The reason of this was that the masonry foundations of these old beam engines were insufficiently heavy to hold down the engine after steam pressure in the boiler had been put up to 30 pounds for engines that were made to be worked with only 7 pounds boiler pressure. Sometimes the cylinder foundations would lift, at others it would be the wall which held up the entablature pillars, and yet again the wall under the crank-shaft bearing. By allowing the steam admission to be gradual the maximum pressure on the piston could not be reached, for the big piston ran away from the capacity of the valve to admit steam quickly. The steam might have been admitted at the dead center, but it would be through a narrow notch lead and the main edge of the valve was too late to let in steam quickly behind the retreating piston. The trouble was variously surmounted in later years by hanging weights to the various foundation walls, bolting them to girders let into the main wall of the building, and later still by the use

of a high-pressure cylinder between the beam center and the connecting-rod. This cylinder counteracted the low-pressure cylinder stresses at the beam center-bearings and was also made to bear somewhat on the crank-shaft wall. It also reduced the upward lift on the low-pressure cylinder wall by converting the low-pressure cylinder again into an atmospheric cylinder. But this by way of digression to explain an exception, which under the peculiar circumstances was allowable.

Why Gas-engine Cylinders are Water-jacketed

The modern steam diagram, then, has a rounded heel, a vertical admission line and a level steam line, and to this pattern it was attempted to bring the gas-engine diagram. It may very well be doubted if such practice is correct. The gas engine is not a steam engine. It is exposed to a working agent of so high a temperature that unless means be taken to moderate the effects of this, the cylinder and piston would become red-hot and would be unable any longer to work together.

In order to obviate this difficulty the cylinder, and in larger engines the piston also, is made with a water-jacket, thereby effectually guarding it against ever becoming, what was so desirable in the steam engine, as hot as the fluid that is within it. The gas engine has, in fact, a water-cooled cylinder and this water absorbs about a third of the heat of the fuel which enters it, or in some cases perhaps only a fourth. Thus at one unscientific blow the internal waste of heat in the gas engine is brought up to that of a very ordinary steam engine, in the cylinder of which some 15 to 50 per cent. of the steam admitted is condensed during admission and more is often condensed after the admission valve is closed.

Now the gas engine always carries a high degree of compression. The contents of the cylinder are compressed up to a pressure sufficient to start the moving parts upon their next forward stroke and this compression starts early, and, even with no reinforcement, will carry the piston some way without the aid of the crank. But in an engine on the Otto cycle this action is omitted every second revolution, or during a non-explosive stroke, and the crank-pin has to pull forward the piston. This fact is a strong argument in favor of the two-cylinder tandem type of engine in which the compression strokes of the two cylinders not coinciding, one or other compression is always ready to push the moving parts and prevent or reduce knocking effects.

But given this high compression, the need for early explosion in a gas-engine cylinder no longer holds. The ignition may be made a bit later and the explosion line may lean forward, so that maximum pressure is attained after the crank has gone considerable angular distance past the dead point. The maximum stress does not act at the dead point, but at a time when the piston is moving rapidly and the gases are obviously still burning when the crank has gone thus far. Theoretically a delayed combustion is a wrong thing in a heat engine, all the heat of the working fluid of which should properly be applied at maximum temperature. But practice and the inevitable conditions of practice compel many modifications from theoretical perfection. When the engine is on its dead point the crank-shaft is rotating at full speed, as usual. When the cylinder contains its minimum pressure at that point the piston is pressing the shaft upon its bearings with maximum intensity, and full braking effect is being generated at the bearings, but no work is being usefully performed, for the piston can do no useful work when not moving, though it can put on a braking effect by causing heavy pressure on the large rotatory piece. Thus while the piston is at rest, there is a heavy pressure of hot gas in the cylinder rapidly giving up heat to the water-jacket, so that much less heat is available to do work.

Suppose, however, that the crank-shaft be allowed to rotate fairly free from frictional loading, past the dead point, and ignition is started slowly and delayed so that maximum pressure occurs behind a rapidly moving piston, then will the heat generated be directly converted into useful work upon a crank at something like a useful angle and capable of work and moving fast.

The Difference as Regards the Cylinders

There is a comparatively short period of exposure to the high temperature of the cylinder surface, whereas with early ignition and high vertical-explosion line the high-temperature gas is standing still idle between two virtually stationary pieces of cold metal, the cylinder end and the piston face, and much heat is then absorbed which under faster movement would go directly to work. Here then we see the difference between the steam engine and the gas engine, as regards the cylinders. One must be kept hot for economy, the other must be kept cool for safety. Let it not be forgotten that the gas-engine cylinder is not cooled in order that it may cool the working gas within it, but in order that its own inner surface may not become too hot for the piston to run on it, or too hot to allow of compression of the charge within it to a desirable degree. If too hot the cylinder would ignite a heavily compressed and therefore self-heated charge, and all gas-engine experts know that some trifling projection, such as a bolt head, will serve to cause premature explosion, because from its projecting length it cannot be kept cool by the jacket and it becomes an igniter, so that an engine will run without any intentional ignition. In fact, the Diesel engine does do so, for its compression is so high that the charge would ignite too early every stroke, so that Diesel avoids this by delaying the charge of fuel until he wants the heat. He then sprays the fuel into compressed air hot enough to ignite the spray and he maintains the fuel spray for some time behind the retreating piston, and the heat thus generated goes at once into work and the loss to the jacket is comparatively small; while the efficiency is high, very largely because of the reduced cooling effect of the water-jacket on the working gases, which are only burned behind a moving piston and generate turning effort directly, when otherwise, with early maximum pressure and full instantaneous explosion, they would be wastefully expended, however correctly used in a narrow theoretical sense. We cannot reason out these things theoretically, and must conform practice to events we cannot control and the necessity of a cold cylinder is one which is, so far, beyond our powers to remedy.

It is clear from the foregoing considerations that the gas engine cannot be worked like the steam engine. The steam engine is a little better machine, theoretically, because it is a machine to be worked nearer to its working-fluid temperature, but it is a less efficient machine than the gas engine in practice, because what the gas engine throws away in its jacket is thrown into the condenser of the steam engine, while the gas-engine furnace only sends away its wastes through the engine, so that the engine exhaust and the furnace exhaust of the steam boiler are reduced to one loss in the gas engine. Then despite the cold cylinder, the working fluid in the gas engine works between a greater range of temperature than does the steam engine, and this renders possible a better efficiency apart from the fact that one uses fuel in its cylinder, the other uses fuel in an outer vessel at atmospheric pressure, and has heat-transfer wastes to the water. The steam engine is less direct, but we should not forget that the gas used in the gas engine only contains a portion of the calorific power of the fuel, and that any attempt to increase the percentage of calorific utilization results in difficulties with regard to compression that may render such attempts undesirable in large engines. But these matters properly belong to another article. In this an attempt has been made to show that it is not correct to regard the gas engine as an exact mechanical and thermal parallel with the steam engine, because they differ fundamentally in the essentials of practice, as far as the treatment of the cylinder in regard to its effect on the working fluid, the effect of the working fluid on the cylinder, and the influence of their essentials of design are concerned, for in all engineering the best economy is a matter of much compromise of warring elements, and this is perhaps more the case with the gas engine than with the steam engine.

Technical Aspects of Oil as Fuel—II

Graphical Analysis of the Conditions which Should Result in the Best Thermal Utilization of Combustible Mixtures

BY FRANZ ERICH JUNGE

After having found a more or less satisfactory method of mixing the oil vapor with the air necessary to support combustion, another no less important problem presents itself, namely, to decide which cyclic process will afford, with the construction at hand, the attainment of maximum economy of operation, that is, the lowest fuel consumption per unit of output.

It is known that in every internal-combustion engine work is done by introducing the heat which is to be utilized

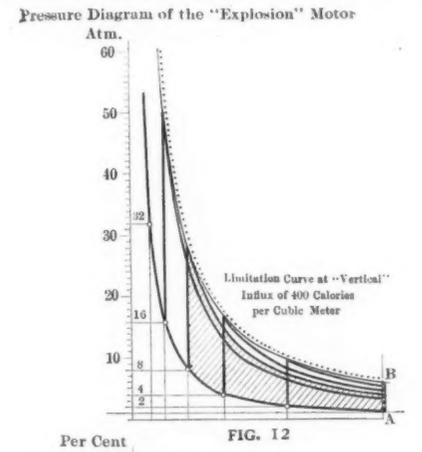


FIG. 12

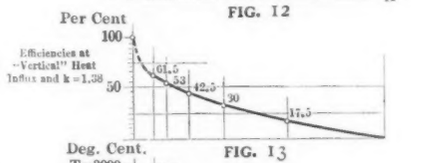


FIG. 13

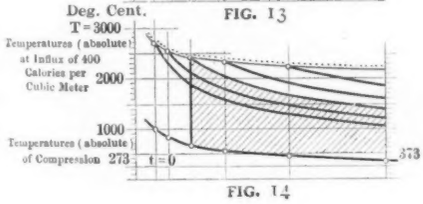


FIG. 14

at a higher pressure and discharging the heat which has not been utilized at a lower pressure. In order to be able to demonstrate the operation of one of the best-known working processes, Kutzbach assumes a definite quantity of air-and-fuel mixture with which the cycle is to be performed. At a temperature of zero Centigrade, and with 760 millimeters barometer pressure, the volume of this weight of mixture is equal to one cubic meter. The resolution of this quantity of gases by combustion into carbon dioxide and steam will yield 400 calories from the time inflammation is provided until the gases have been cooled down to their original temperature.

This combustible gas-and-air mixture, representing 400 calories of thermal energy, is supposed to be inclosed in the cylinder of an internal-combustion engine, where it is compressed by the piston, with an expenditure of a certain amount of negative work, and afterward ignited. Thereby the 400 calories are liberated and are introduced into the process at such a rapid rate that the increase of pressure may be represented on a diagram by a practically vertical line, which would be indicative of explosive combustion; that is, combustion at constant volume. When the influx of heat and, therefore, the combustion are ended (theoretically), the mixture is allowed to expand to the original volume, and considerable work is produced and transmitted through the piston. At the end of the expansion stroke, that part of the heat which has not been transformed into work is suddenly discharged. This can be done, for instance, by injecting cold water into the

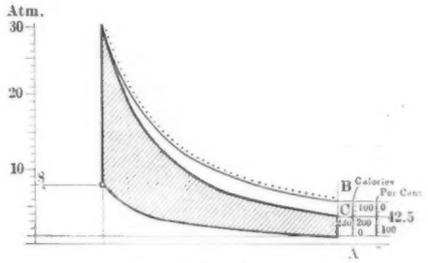


FIG. 15

hot gases in order to absorb their heat, but in practice this result is ordinarily attained by allowing the burnt charge to escape into the atmosphere, replacing it by fresh gases.

Diagrams Showing Pressure and Volume Changes

The changes of pressure and volume which accompany this transformation of kinetic into mechanical energy may be graphically represented in an indicator diagram the area of which is directly proportionate to the work rendered. The diagrams shown in Figs. 12, 13 and 14 have been computed and drawn for compression pressures two, four, eight and sixteen times higher, respectively, than the initial pressures under the assumption of constant specific heat. By connecting the upper terminal points of all explosion lines, which are the graphic expressions of vertical heat influx, a definite limitation curve is obtained which represents the introduction of 400 calories into the working process in the manner stated. The starting point point *B*, Fig. 12, of the limitation curve which corresponds to the initial volume is found by igniting the air-gas mixture at *A*, before the beginning of compression, and by plotting the corresponding pressure distance *A-B* on the extreme right-hand ordinate. The distance *A-B* represents, therefore, either the influx, or, to return to the starting point *A*, the efflux of 400 calories. Assuming constant specific heat, it is easy to construct the limitation curve of explosions for different compression pressures by plotting an isothermal (hyperbolic) curve

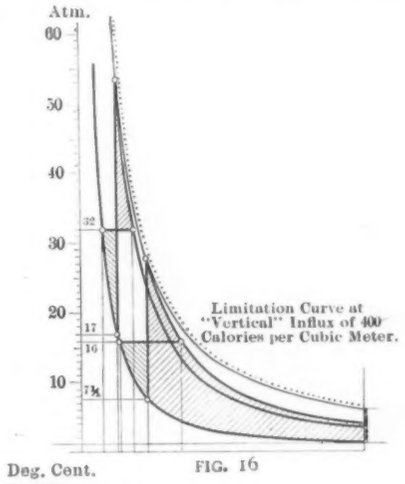


FIG. 16

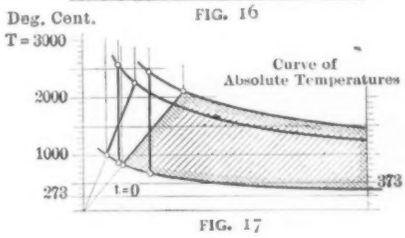


FIG. 17

through the point *B* and adding the ordinates to those of the compression curve. For, in the temperature diagram, the limitation curve of temperatures shows an invariable difference with reference to the temperatures of the compression line. From Fig. 12 it will be seen that the expansion lines which start from the single points of the limitation curve arrive at the ordinate *A-B* at pressures which become lower the higher the charge is compressed before ignition. These terminal pressures afford a measure of comparison of the quantities of heat that must be disposed of with the different cycles, it being obvious that the higher the terminal pressures of the expanded gases, the more

heat must be carried away in order to arrive again at the initial condition *A*, which is in this case atmospheric pressure. The point *B* of the limitation curve corresponds, then, to the deduction of 400 calories, and the distance *A-B* divided into 400 parts is a scale for measuring the quantity of heat carried away. Now considering the diagram, Fig. 15, in which compression has been carried to eight times the initial atmospheric pressure, it is seen that expansion ends at the point *C*,

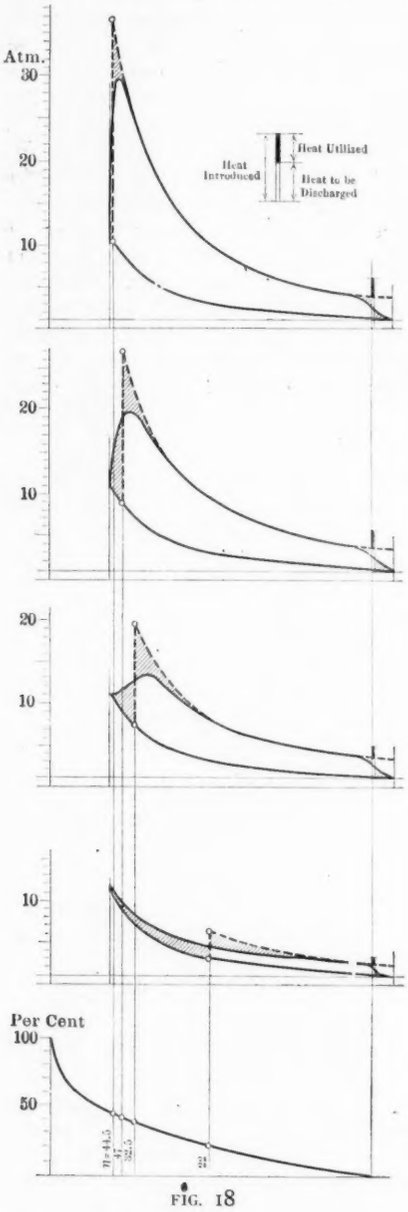


FIG. 18

and that the heat carried off is 230 calories, as against the 400 that were introduced Therefore, the formation of the diagram, or the amount of useful work thereby represented, has required 400 — 230 = 170 calories, and the thermal efficiency of this process is $\frac{170}{400}$ or 42.5 per cent., a result which can be read from the right-hand scale at once.

The thermal efficiencies corresponding to the different points of the compression line, which were deducted from the diagram, Fig. 12, in the way just explained, are plotted in Fig. 13. It will be seen that at a compression of 16 atmospheres, or when compressing to sixteen times the initial pressure, the thermal efficiency is theoretically about 53 per cent., if the exponent of the compression line is assumed as $k = 1.38$. It is to be noted that the curve of efficiencies remains identical regardless of the quantity of heat introduced.

From this analysis of working cycles with vertical heat influx Kutzbach arrives at the conclusion that engines working with quantity regulation and invariable-compression ratio must have the same cyclic efficiency throughout the range of loads, notwithstanding the fact that the pressure of compression decreases considerably at the lower loads. Of course, losses due to increased pump work, throttling and other resistances will reduce this efficiency somewhat, but it is maintained that in spite of these losses internal-combustion engines working with throttle or cut-off regulation have a superior neat efficiency to others, even at the lower loads and when compression pressures are reduced. From the foregoing consideration Kutzbach concludes that attempts to maintain the compression of the dynamic charge constant while varying its quantity are based on wrong suppositions, as long as the aim of the builder is to improve on the thermal efficiency of the process rather than to simplify the construction of the machine.

Numerous Losses Occur in Practice

In reality the execution of a theoretical gas cycle in a practical machine always

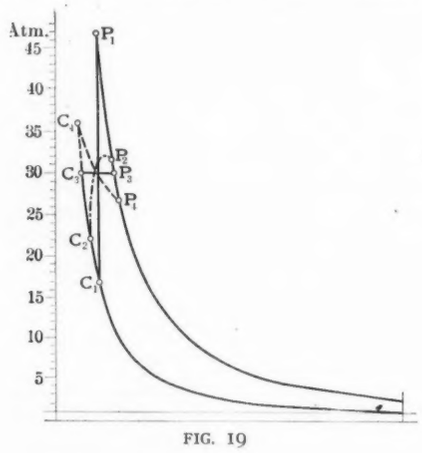


FIG. 19

entails numerous losses which occur, especially, during the introduction and the discharge of the working medium, and through heat transference to the cylinder walls. With sixteenfold compression the thermal efficiency, based on the indicated output, will not be much higher than 40 per cent. But these losses are unavoidable in all thermo-dynamic processes and have no bearing on the final conclusions.

In Fig. 14 the course of temperatures of the single processes is represented in a curve showing the absolute temperatures. It is significant to note how with increasing compression pressures the temperature of the air-gas mixture increases—at first slowly, afterward faster. This feature is characteristic and in a measure is responsible for premature ignition which sometimes occurs in the cylinders of internal-combustion engines. Inasmuch as the diagrammatic area which is circumscribed by the gas-volume and gas-pressure curves represents, immediately, the work output or kinetic capacity of the one cubic meter of air-gas mixture on which the cycle was performed, these areas must grow larger, when the compression ratio increases, exactly in proportion to the increase in efficiency. This is confirmed in Figs. 12, 13 and 14.

A second important conclusion which can be drawn from the preceding analysis is as follows: If with equal heat influx (400 calories) and equal scales we can produce diagrammatic areas that are identical, regardless of what may be the course of the expansion line, then the thermal efficiencies of the respective processes must also be equal.

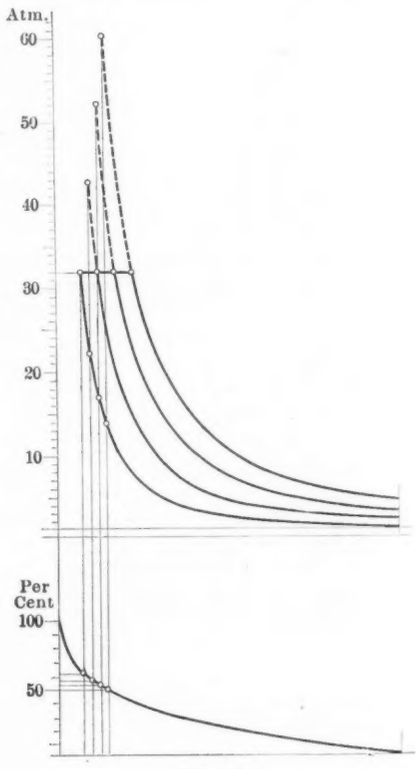


FIG. 20

In Figs. 16 and 17 two constant-pressure diagrams, with horizontal heat influx, and two corresponding constant-volume diagrams, with vertical combustion line, are drawn to the same scale. Since we are familiar with the efficiency of the first-named process we know also the thermal value of the "constant-pressure" diagram. This method can be pursued for various forms of diagrams, as has been done in Fig. 18, which shows a series of diagrams representing the working process

of two-stroke-cycle engines. It is known that two-stroke-cycle engines having exhaust slots cut in the cylinder walls cannot employ any other mode of regulation than that of varying the quality of the mixture according to the load. Therefore rapidity of flame propagation and combustion both decrease with decreasing heat influx—and so does the efficiency; at no load, for instance it is theoretically only one-half of the maximum.

Which Cycle Is Best to Adopt

Since in every heat engine the maximum pressure occurring in the working process determines the strength, dimensions of the driving parts and the weight of the machine, there arises the other question: Which cycle is the best to adopt when the maximum pressure is given? The diagrams in Fig. 19 have all the same area. According to Kutzbach's theory they must, therefore, all represent equal efficiency of heat utilization. As the maximum pressures of combustion P_1 to P_4 decrease, the pressures of compression C_1 to C_4 increase. The lowest maximum pressures occur when $C_3 = P_3$, that is, when combustion takes place at constant pressure. When the maximum material stresses are limited, for reasons of safety, to values approaching C_3 or P_3, then it is obvious that all the other systems which could be employed must work with inferior heat efficiency. In other words, *with given maximum pressure, constant-pressure combustion will secure the highest efficiency.*

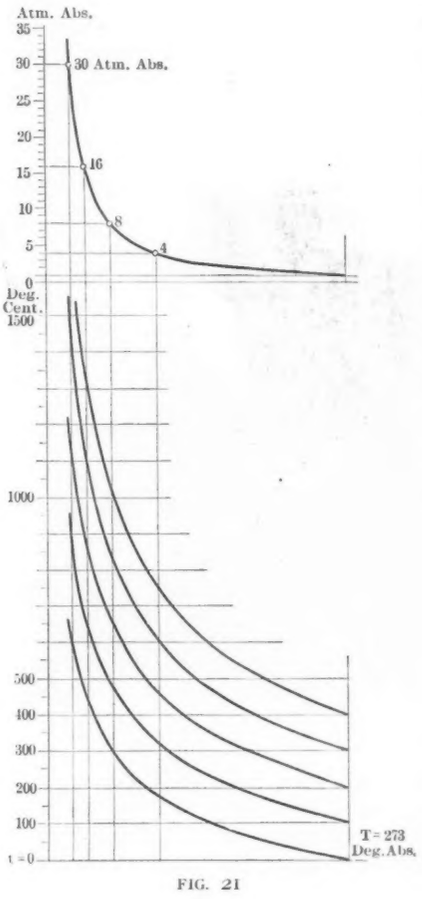


FIG. 21

Another conclusion is this: With constant-pressure combustion the efficiency increases as the heat influx decreases. For, the diagrams in Fig. 20, having equal areas and instantaneous heat influx, show increasing compression pressures, while it was demonstrated earlier that with explosive heat influx the cyclic efficiency remains constant under all conditions, irrespective of the quantity of heat introduced into the process. Further: When the compression ratio is fixed, or, for instance, when it is determined that the gas shall be compressed to sixteen times the original volume, then the highest efficiency will be attained with instantaneous or explosive heat influx. It will be shown later which are the factors, besides those of construction, that determine this ratio of compression. For those interested in the discussion of theoretical working cycles it will be of value to compare the above analysis by Kutzbach with the results of a similar investigation made by Weidmann, which was presented in a paper entitled, "On the Evolution of Gas Power," at the meeting of the American Society of Mechanical Engineers in December, 1906.

In the first article of this series, published in the October number, there were described different methods of introducing heat into the working medium. The simplest was to aspirate the fuel, together with the air, into the cylinder, there to compress it to the safe and economic pressure limit, and then to ignite it. After provoking inflammation it is not possible, with the majority of constructions, to control combustion so that the heat influx line of the diagrams extends more or less vertically, depending on numerous agencies which would require too much space to discuss in this article.

The Danger of Self-ignition

In addition to considerations of economy, the upper limit of compression of a combustible mixture is rigidly drawn for each fuel by the danger of self-ignition, which may be provoked through contact with hot surfaces by the temperature increase of the mixture. At the beginning of compression there is contained in the cylinder a gas-air mixture the constituents of which lack uniformity of temperature. Those places which are not reached by the incoming fresh gases, especially the indicator holes, or ports in the neighborhood of the hot piston-head or of the starting valve; likewise, all gas molecules located near incandescent particles of lubricating oil, or in the neighborhood of uncooled metallic surfaces, as, for instance, near the incandescent chamber; all these have temperatures higher than the mean temperature of the mixture and their temperatures rise correspondingly during compression. Thus, with eightfold compression the mixture proper is not heated higher than from 100 to 500 degrees Centigrade, while at some points where exhaust gases of 400 degrees Centigrade remain from the former combustion, a temperature of 1000 degrees Centigrade will prevail. See Fig. 21. These overheated spots are probably responsible for self-ignition or premature ignition of combustible mixtures toward the end of the compression stroke. Depending on the form of the compression space an engine will be more or less sensitive in this respect. There are also other preventives, such as scavenging the entire compression chamber with fresh air, or cooling the hot gases by the injection of finely distributed cold water; both methods have been adopted with fair success. Yet the gain in the rate of compression is comparatively small unless recourse is had to the instalment of additional apparatus, both complex and costly.

Little accurate knowledge is available as to which constituents of a gas-air mixture are apt, according to their quantity, to shift the beginning of self-ignition farther up or down; also whether catalytic action on the walls has something to do with it. It is a fact that hydrogen and those hydrocarbons which are rich in hydrogen contents ($C_n H_{2n+2}$, for instance), like gasolene and petroleum, will promote self-ignition, when forming a large percentage of the mixture, while the hydrocarbons of the benzol series (C_6H_6), with low hydrogen contents, are less apt to do so. Carbon dioxide and water vapor, on the other hand, will prevent premature ignition. (In an earlier investigation Kutzbach had determined that 5 per cent. of hydrogen in a mixture of producer gas and air is permissible for attaining high compression, leaving out of consideration the damping action of CO_2 and H_2O.) In one cubic meter of mixture of gasolene vapor and air, with no excess air, are contained 13.4 grams

Theoretical Pressure Diagram of Diesel Engine

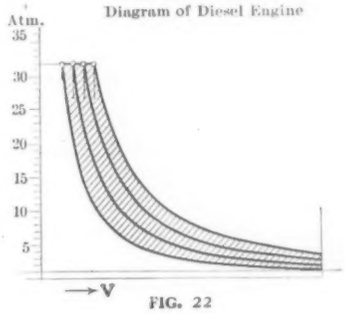


FIG. 22

Diagram of Absolute Temperatures

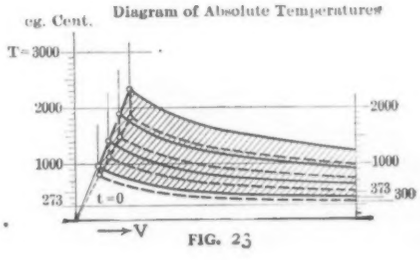


FIG. 23

of hydrogen; in a mixture of benzol vapor and air only 7.3 grams, or 5 grams of hydrogen, with 50 per cent. excess air.

It is remarkable that those hydrocarbons which are rich in hydrogen content will decompose at temperatures of 400 to 500 degrees Centigrade, forming oil gas, the principal constituents of which are H, C_2H_6, and CH_4. Benzol, on the other hand, will not decompose. The production of oil gas is undoubtedly responsible, at least to a certain extent, for the occurrence of self-ignition in oil engines.

On the basis of the considerations and facts mentioned the designer must construct his machine. Thus we find the small automobile motors compressing only up to 5 atmospheres or so; petroleum and oil engines of ordinary construction cannot use higher compression pressures than from 3 to 7 atmospheres; and it is only by cooling the compression space internally through water injection (as is now done by Weyland, Banki, Priestman, Griffin and others) that the danger of

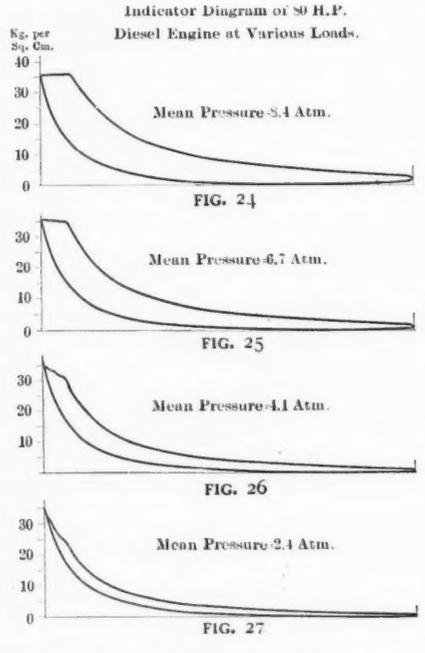


FIG. 24

FIG. 25

FIG. 26

FIG. 27

pre-ignition and knocking at higher compression pressures can be positively counteracted, and the economic compression limit raised to 8 or 10 atmospheres. But since the internal cooling of the walls is unfavorable to good evaporation, this process is again limited in application.

Another question that remains to be clarified is whether we shall succeed in finding, among the cheaper coal-tar oils, fuels which can stand high compression and therefore enable one to burn them in internal-combustion engines with highest thermal efficiency. This subject will be amplified later.

In judging of the applicability of a certain type of engine for certain uses it should be remembered that the danger of premature-ignition troubles increases with the size of the engine, or at least with those of the ordinary type, because on the one hand the cooling influence of the water-jacketed cylinder walls grows smaller, while on the other hand uniform mixing of the charge constituents becomes more difficult. There is also danger that those particles of the mixture which are easily inflamed may ignite when coming in contact with incandescent residues.

Difficulties Avoided in the Diesel Engine

All these difficulties which arise when aiming toward higher compression pressures in engines working on the ordinary (Otto) cycle are avoided in the Diesel engine, in which air alone is compressed in the power cylinder, while the formation of the mixture is performed according to system No. 8, illustrated by Fig. 11, in the previous issue.* This mixing process was employed by Brayton with certain modifications as early as 1872. (Compare with Professor Carpenter's discussion, *Proceedings* of the American Society of Mechanical Engineers, January, 1907.) The thermal superiority of the Diesel engine over all its predecessors and competitors consists in the possibility of securing, in addition to an ideal mixture, any rate of compression desired without fear of premature ignition, with all its resulting dangers and drawbacks. Compression, even, is carried so far that the fuel is ignited in and through the highly treated air without depending on any special ignition system, incandescent tubes, or similar appliances. The usual compression pressures employed in the Diesel engine are between 30 and 40 atmospheres, which give compression temperatures sufficiently high to produce the ignition of the injected fuel.

From Figs. 22 and 23 can be seen the temperature and pressure conditions which occur in modern Diesel engines. In the temperature diagram is given the cycle of temperatures at various loads, the dotted line showing the course of the lower initial compression temperature such as exists when starting the engine from cold. Indicator cards taken from Diesel engines in actual operation, Figs. 24, 25, 26 and 27, show apparently constant combustion lines, at least at the higher loads. (Regarding the influence of the form of the inlet nozzle and, after burning, the course of this line, see Professor Carpenter's paper.) The characteristic features and merits of the Diesel engines are summarized by Kutzbach in the following debatable claims: 1. Compression of air alone; therefore impossibility of premature ignition. 2. Compression from 1 atmosphere up to 30 and 40 atmospheres; therefore excellent heat utilization. 3. Generation of such high temperature that the fuel is at once ignited by mere contact with the highly heated compressed air; therefore no special ignition from without is required. 4. Uniform mixture of fuel and combustion air is attained by injecting the liquid fuel, by means of compressed air of higher pressure, into the combustion air, which is compressed in a small space; therefore perfect combustion is secured without soot, residue or deposit of any kind, and without odor. 5. Capability of regulation of the fuel admission in such manner that combustion progresses, approximately, at constant pressure; therefore resulting in best thermal utilization for a given strength of the driving parts.

*POWER for October, 1907, page 667.

A Unique Boiler Plant

By H. Cole Estep

One of the striking features of nearly every Pacific-coast sawmill is the refuse pile. It is customary to burn the sawdust and some of the refuse of the mill under the boilers, but the rest of the refuse, which is considerable, is usually piled in a heap outdoors and burned, as it is considered cheaper to dispose of it in this way than to make provision for handling and firing, under ordinary boilers, the miscellaneous material that comes from the refuse conveyer. Thus the refuse pile (a place where dollars are burned) is considered by most mill men to be a necessary evil. Some of them, however, have attempted to prevent this dissipation of more or less useful material, and one company at least seems to have solved the problem. This is the Moran Company, of Seattle, which, in addition to a large sawmill, operates the largest steel and wood shipbuilding plant north of San Francisco, and which has installed especially designed boilers under which to burn *all* of the refuse from the sawmill, including slabs, sap-wood, split ends of boards, etc., which come from the mill in all sizes and shapes.

FIG. 1. THE BOILER HOUSE

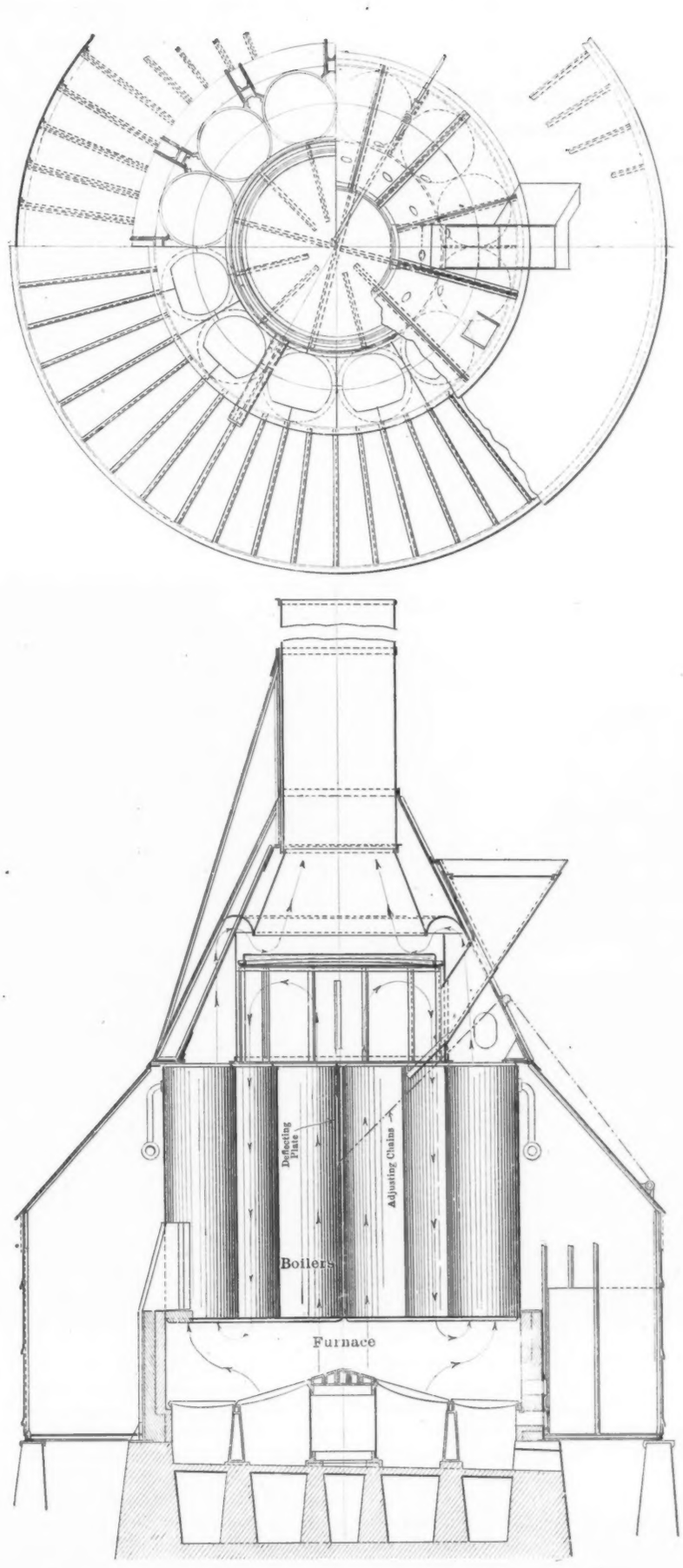


FIG. 2. PLAN AND ELEVATION OF THE MORAN COMPANY'S BOILER PLANT

The power plant, which operates the sawmill by steam and the shipbuilding shops by electricity, includes two 1000-horse-power, vertical compound condensing engines, one 400- and two 125-horse-power high-speed automatic condensing engines, with a total normal capacity of 2650 horse-power. There are twelve vertical multi-tubular shell boilers, of 225 horse-power each, set touching each other in a circle 19 feet 8¾ inches in diameter, as illustrated in Fig. 2. Each boiler is 5 feet in diameter and 18 feet long. They are set snugly together and the external sections are heavily coated with magnesia boiler covering. Each boiler is individually supported on the concrete foundation and due allowance has been made for expansion and contraction. There are eighty-seven 2½-inch tubes in each boiler. The average working pressure is 135 pounds per square inch.

Inside the battery is a circular combustion chamber 14 feet 6 inches in diameter and 18 feet high. The top of this chamber is closed by a sheet-iron dome 15 feet in diameter and 6 feet high. Completely covering this dome and flaring to the outer edge of the circular row of boilers is a conical sheet-iron shell 26 feet in diameter at the bottom, 8 feet at the top, and 18 feet 6 inches high. The steel stack, 8 feet in diameter, fits into the top of this conical shell. Underneath the boilers is a circular furnace 24 feet 10 inches in diameter. The grates are supported at the center by a steel pier 4 feet 4½ inches in diameter and 6 feet 5½ inches high. The combination of grates forms a flat cone, with its apex two feet above the base. Not including the boiler house, the plant looks very much like an enormous, upright donkey-engine boiler.

The refuse conveyer from the mill dumps the material into a sheet-iron hopper situated 40 feet above the floor level. From the hopper the refuse falls into a square chute, 2 feet 6 inches by 3 feet, which leads into the circular chamber under the dome. Here the fuel strikes the deflection plates and falls in a fairly even layer on the grates below.

The chamber under the dome, into which the refuse falls, is usually half full of burning fuel and subjected to intense heat, much of which is absorbed by the adjacent boiler shells. After combustion, the hot gases pass up through the tubes in the ordinary manner and come out in the conical chamber surrounding the interior dome; from here they pass through the spark arrester and find their way up the stack. The top of the stack is 140 feet above the floor level, so there is ample natural draft.

A 7-inch header in the form of a ring surrounds the 12 boilers, from each of which is tapped a 4-inch copper pipe leading into the header. Inasmuch as the upper ends of the boilers and a portion of

the tubes are subjected to heat from the combustion chamber, the steam delivered into the header is materially superheated, so that the boilers easily attain normal economy. The feed-water connections screw into special cast-iron fittings at the lower ends of the boilers. Each boiler has its individual safety valve, gages, blow-off and other fittings. The ashes drop into a circular pit containing the ash conveyer, which carries them out and deposits them in the bay. The boiler house (Fig. 1) is of sheet iron, circular. There is a space of 8 feet 3 inches between the boilers and the inside wall of the house.

These boilers are as nearly automatic as can be in a plant of this size. One man on each shift operates the battery easily and efficiently. If repairs are required on any boiler it is not necessary to shut down the whole battery while the defect is being remedied, but the pipe connections are unfastened and with a nearby derrick the boiler is removed bodily, the hole left in the combustion chamber being temporarily bricked up. This has been accomplished in a single night without causing one hour's operating delay.

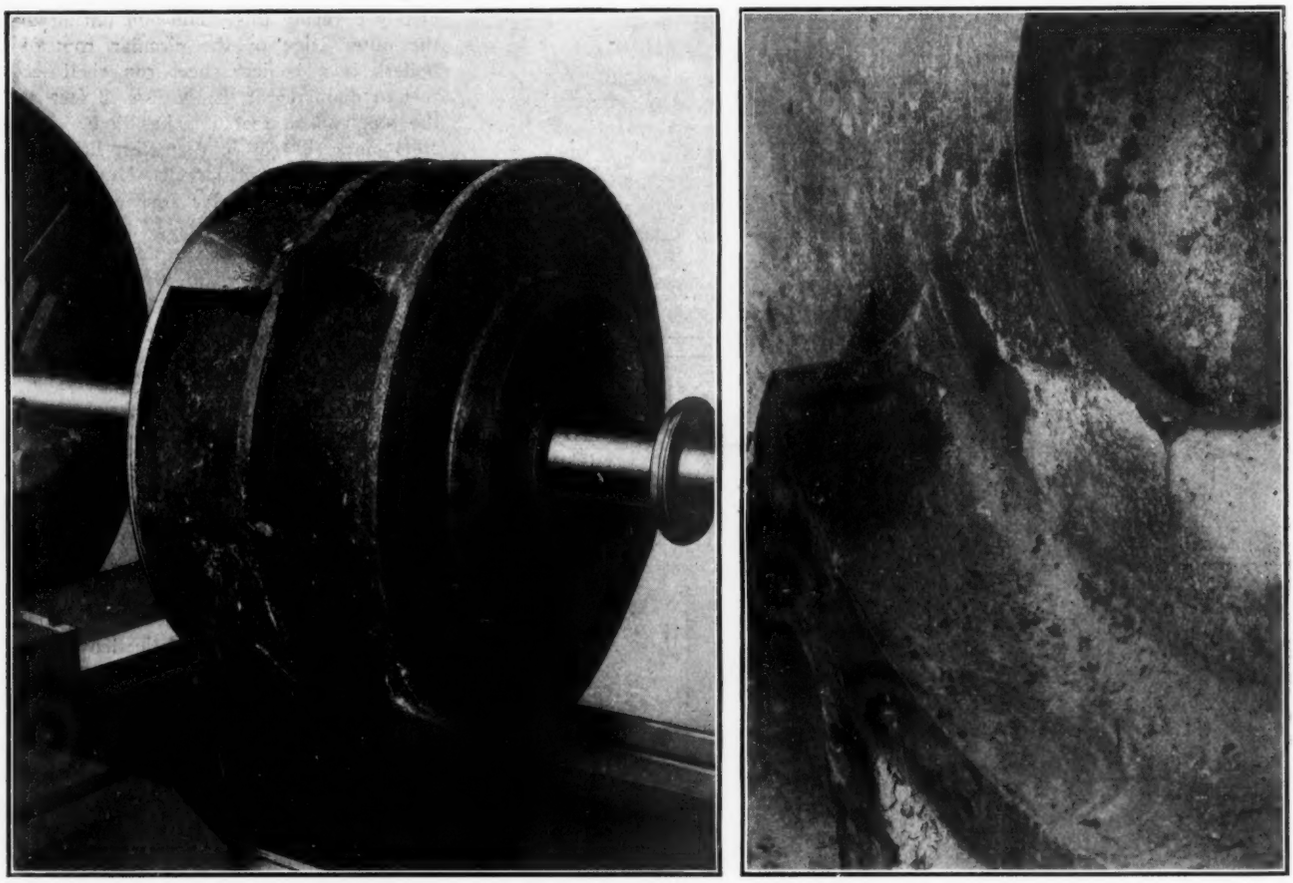
The plant is operated very cheaply, the cost being but a little above the labor expense, and at the present Pacific-coast prices for coal more than $100 per day is saved in fuel alone.

The plant was designed by Robert Moran, founder and first president of the company.

What Caused the Pitting and Corrosion?

A correspondent sends us the accompanying photographs of the runner blades of a centrifugal pump used for circulating water for condensers for the main generating station of the Edison Illuminating Company, of Detroit, located on the bank of the Detroit river. It will be noticed that the blades appear to have become quite soft, in fact porous in places and rotted away.

These are direct-coupled, motor-driven three-phase pumps, of which the company uses a number, some of which are thoroughly insulated while others are not, but all suffer the same. The water is believed to be pure and free from any chemical that might attack iron. Can any POWER reader give the reason for this condition?



WHAT CAUSED THE PITTING AND CORROSION?

The *Woodworker* remarks that "there is no waste so wasteful as economy overdone." This is of particular application in the power plant.

The "Drop" Method of Testing Armature and Field-winding Resistance

By E. S. Lincoln

The "drop" or fall-of-potential method of testing resistances is a most important one, as many other tests are based upon it. It is a method in which Ohm's law is put into practical use, and although very simple, its application requires care, if accurate results are desired. For making measurements, there should be at hand two instruments, an ammeter and a voltmeter, although the ammeter could be dispensed with and a known resistance substituted. It is preferable to use the two instruments, however, especially as the results will be more accurate. The first case to be considered here will illustrate the principle which applies to all.

It is assumed that the resistance of an armature of a small motor is to be determined. The connections are shown in the accompanying diagram, in which the armature is indicated at *C* and its brushes are shown at *B B*. The current enters the system through the switch and cut-out at *S*, and completes the circuit through the ammeter *A*, the motor commutator and the bank of lamps *L*. It is essential to

make sure that the fields are disconnected. In place of the bank of lamps, another form of resistance may be substituted, but where small currents are used a lamp-bank forms a very convenient and easily regulated rheostat.

The voltmeter terminals are connected to the segments of the commutator, and this connection must be very carefully made. Good results may be obtained by soldering each lead of the voltmeter to a small strip of sheet copper, about the size of the end of the brush, and placing the strip between the brush and commutator. All connections should be free from grit and grease, of course. When four or more brushes are used, the resistance should be measured between each set and the average taken as the final resistance of the armature. By each set is meant two brushes of different polarity. If necessary, the armature should be blocked to prevent its turning.

How the Result Is Reached

Assuming that the armature under consideration is that of a 1-horse-power 110-volt motor, its full load current will be about 9 amperes. Using 32-candle-power lamps in the rheostat, the first reading will be with 4 lamps and the second with 7 lamps. Suppose that at the first reading the ammeter indicated 4 amperes, and at the second 7 amperes, while the first reading of the voltmeter was 8 volts and the second 14 volts. It follows that in both cases the resistance was 2 ohms, since

$$R = \frac{E}{I}, \; R = \frac{8}{4} = \frac{14}{7} = 2.$$

It is best to take several readings with different currents, averaging them for the final result. The resistance of other parts may be measured in like manner, or the armature and brush resistance may be taken together by placing the voltmeter leads at the points indicated by X and Y on the diagram. With a little practice one can usually estimate about what value will be obtained. The voltmeter in the case assumed should have a 9 to 15 scale, but the readings always should be tried first on the high scale.

As intimated, if no ammeter is available a known resistance may be used in its place, connected in the same way. In such case the voltage is taken at the terminals of the known resistance and the current is figured out by Ohm's law, $I = \frac{E}{R}$, where R is the value of the known resistance. When measuring the contact resistance between a brush and commutator, be sure to have the voltmeter lead connected to all the segments with which the brush comes in contact. Simultaneous readings should be taken, and steady current should be available. A storage or strong primary battery will give good results.

When connecting the voltmeter leads to the different parts of the machine, be sure that the circuit is in no way broken, or it will allow the full voltage to act on the low scale of the instrument and burn it out. This may be clearly understood by referring to the diagram again. If, for instance, the voltmeter leads were connected to the brushes $B\,B$ at the points X and Y, and one brush were lifted off the commutator, it would allow the full voltage of the circuit to act on the low scale instrument, with the result stated.

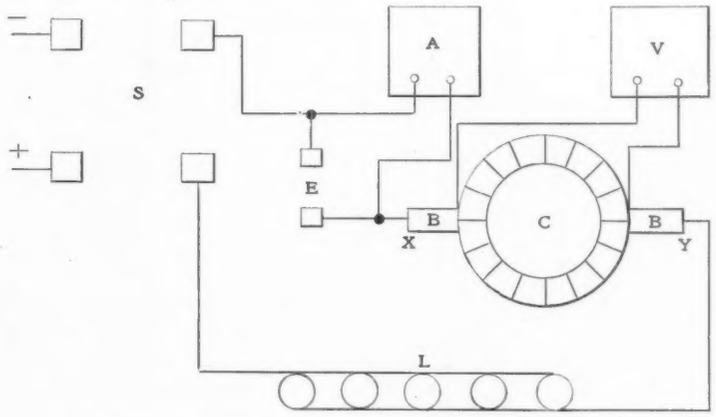


DIAGRAM OF CONNECTIONS FOR TESTING RESISTANCE

In testing any machine winding it is best to use as strong a current as possible so as to obtain a good reading on the voltmeter, but the full load capacity of the winding should never be exceeded. Moreover, a strong current should not be kept flowing for any length of time before readings are taken, as it will heat the circuit and change its resistance.

In measuring the resistance of a wire by the "drop" method, be sure not to allow more current to pass through it than that given by a table of safe carrying capacity. Although the wire will carry a larger current than that given in the table, it is better not to exceed its rating.

Measuring Shunt Field Resistance

In measuring the resistance of a shunt field winding it should receive the voltage for which it was designed. In the example cited, the voltage would be 110, and no additional resistance would be required. If the ammeter reading were one ampere the resistance of the field winding would be 110 ohms; $R = \frac{110}{1}$. Never take any readings of the instruments when the circuit is first made, but allow the field magnet to become fully magnetized. Again, before breaking a field circuit it is *very* important that the voltmeter should be disconnected, as otherwise it would receive a very high momentary voltage, due to the self-induction of the magnet. The field circuit should be broken very gradually, and this may be accomplished by allowing the controlling switch to arc when disconnecting the winding. Just before disconnecting the windings of large field or other powerful magnets, an external resistance should be inserted in series with them in order to reduce the current and thereby subdue the "back-kick." It should be remembered that this "kick" is injurious to the operator as well as to a voltmeter.

When measuring the resistance of a field winding it should always be disconnected from the brushes. In some cases the field rheostat will be useful to regulate the current in the field circuit, but care should be taken not to injure it. If the field rheostat is connected in the circuit, its resistance must not be included with the field-winding resistance. The voltmeter leads should be connected to the field-winding leads as near as possible to the points where they leave the winding. If it is desired to obtain very accurate results in measuring field-winding resistances, or the like, the ammeter should be connected as near as possible to the field winding and the voltmeter connected outside the ammeter, so that the latter will not record the small current taken by the former. As the instrument will be affected by the magnet field, it should be connected to the field winding by a conductor which will carry several times the field current. The slight added resistance of a few feet of this conductor will not cause an appreciable error in the final results. Of course, this added resistance and the resistance of the ammeter can be subtracted from the total resistance, if desired.

In a paper on "The Steam Turbine on Land and at Sea," presented before the Royal Institution of Great Britain by Hon. Charles A. Parsons, the speaker stated that to form some idea of the forces at work in a turbine we should consider, with approximate accuracy, that the steam flows through the turbine with a force about ten times as great as that of the strongest hurricane; and though the force acting on each blade is small, perhaps only a few ounces, or in the largest only a few pounds, yet in the aggregate the force is great and can propel large ships or drive large dynamos.

The Hydraulic Elevator—XI

The Electrical Features of Vertical-cylinder Elevators; Operation and Care of Pilot Valves and Connecting Mechanisms

BY WILLIAM BAXTER, JR.

This article will be confined to a consideration of the purely electrical features of vertical-cylinder elevators and the mechanical devices that operate in connection with them. The general arrangement of the various parts of a magnetically controlled vertical-cylinder hydraulic elevator may be seen by reference to Fig. 111, which shows the arrangement of the pilot valve and the secondary pilots used for operation by battery, or alternating current, the electrical features being the same as in those designed to be operated by current taken from an incandescent-lighting circuit. The magnets that move the pilot valve are located at *A*. They are connected with the batteries and the floor controller *D* by means of wires carried in the cable *B*. The arms *C* of the floor controller are connected with relay magnets, contained in the magnet box shown, by wires in the cable *E*, while other wires in the cable *F* connect the relay magnets with the push-buttons located at the sides of the elevator doors on the several floors. From a point *G* located half way up the elevator well is suspended a cable *H* which carries the wires connecting with the push-buttons in the car. The manner in which the relay magnets are connected with the floor and car push-buttons, and also with the contact rollers on the floor controller, is clearly shown in the wiring diagram, Fig. 64, which was published in the July instalment of this series, and which is reproduced on the next page.

The purpose of the floor controller is to control the direction of movement of the car whenever a push-button is depressed. If the car is above the floor with which the button corresponds it will run down, and if below the floor it will run up to that floor. From this it will be seen that the floor controller is virtually a reversing switch, so made that the point at which it effects the reversal is controlled by the position of the car in the elevator well.

Two views of the floor controller are shown in Fig. 112, and from these it will be seen that the contact arcs *d d'* of Fig. 64 are replaced in the actual machine by the spiral strips *a a'*, Fig. 112. This construction is used to permit the contact rollers *b b* to pass over the break between the ends of *a* and *a'*, moving with sufficient velocity to prevent injurious sparking. The break *D*, Fig. 64, is shown at *d* in Fig. 112. In order that the contact rollers *b b* may pass from the contact strip *a* to the strip *a'*, or *vice versa*, at the right time, the drum of the floor controller is rotated by means of a sprocket-wheel and the chain *J*, Fig. 111, and the gearing is proportioned to allow the roller corresponding to each floor to pass the break *d* at the time the car is passing the floor. The break *d* consists of a "dead" piece of such length that the circuit between the roller and the contact strip is broken shortly before the car is

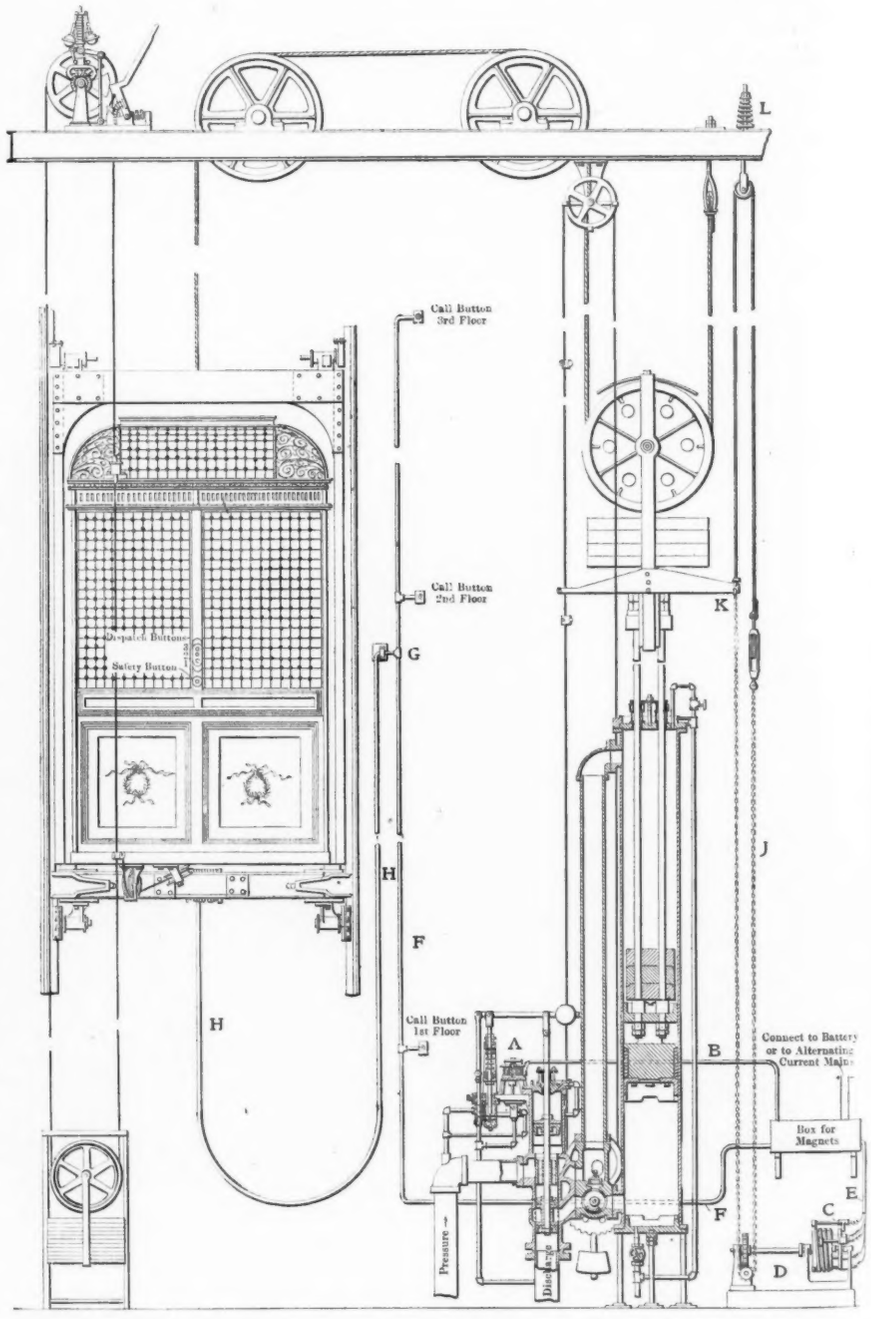


FIG. 111. GENERAL ARRANGEMENT OF VARIOUS PARTS OF A MAGNETICALLY CONTROLLED ELEVATOR

even with the floor, whether going up or down. The distance from the floor at which the break occurs is just enough to cause the car to come to a stop on a level with the floor.

Need of Keeping Contacts Bright

The current passing through the floor controller is very weak (about one ampere), so that it cannot cause much sparking when the rollers *b b* pass off the ends of the contact strips; nevertheless, if the ends of the contacts are permitted to become badly burned the duration of the sparking will become increased, and this will not only cause increased burning at the ends of the strips with each succeeding break, but it will also cause the car to travel slightly farther before stopping. Thus it will be seen that to prevent rapid deterioration of the ends of the contact strips *a a'*, and of the rollers *b b*, as well as to secure accurate stopping of the car, it is necessary to keep these parts bright all the time. It is also essential to keep the surfaces of the contact strips bright all over, for as will be seen in Fig. 64, the current that actuates the valve-lifting magnets passes through these strips, and also through the relay magnets, and if sufficient corrosion or dirt should accumulate to stop the flow of current, or even to reduce its strength so that it would not hold the relay magnets closed, the circuit would be broken and the car would stop. The sprocket-chain *J* must be kept properly adjusted so as not to slip off the teeth of the sprocket-wheel, but at the same time it should not be so tight as to lift on the controller shaft sufficiently to cause the bearing to run hot. The drum of the controller is arranged to run on a thread so that it may travel endwise as it rotates, and thus keep the contact rollers *b b* on the contact strips *a a'*. The pitch of the thread on which the drum runs is the same as that of the strips *a a'*. The floor controller shown in Fig. 112 is slightly different from that shown in Fig. 111, in that it has a large driving sprocket on the end of the shaft, in place of a small sprocket and a worm-gear reduction; in every other respect the construction is identical.

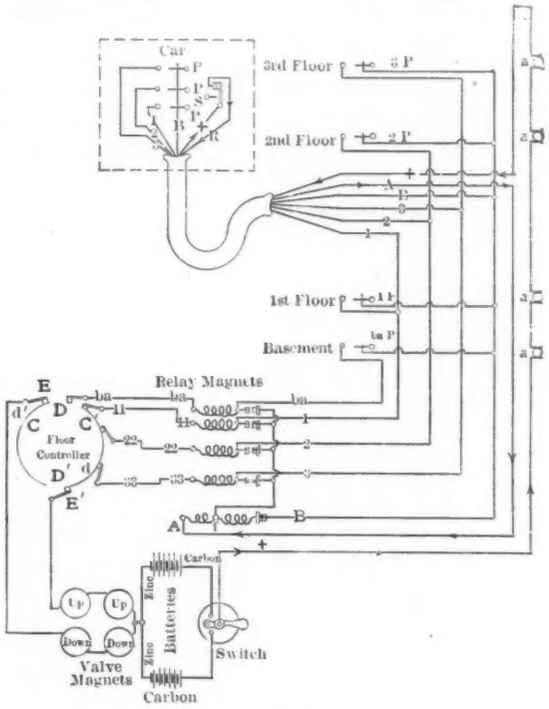


FIG. 64
(Reproduced from July POWER.)

Care of the Relay Magnets

In the magnet box shown in Fig. 111 are placed the relay magnets, and as the successful operation of the elevator depends on the proper working of these, they should be examined frequently and kept in good condition. All they require ordinarily is to be kept free from dust, and the contacts should be kept bright to prevent injurious sparking. The best way to keep contact surfaces bright, on both the floor controller and the relay magnets, is by the use of fine sandpaper, about No. 0. To prevent injury to the insulation, the parts through which electric currents pass must be kept well protected from water, and even moisture. As a rule, when the apparatus is installed all the electrical parts are placed where they are not exposed, but sometimes in making changes in a building the necessity of keeping these parts perfectly dry is lost sight of, and then trouble begins. The only parts of the electrical apparatus that cannot very well be removed from where they are liable to be damaged by water are the two sets of magnets that actuate the pilot valve; these must necessarily be placed at *A*, Fig. 111. To protect them as much as possible, they are insulated as a whole from the valve casing in the manner shown in Figs. 113 and 114, the former being the type of controller shown in Fig. 111 and the latter the type used when the operating current is taken from a lighting circuit. In Fig. 113 it will be seen that the bolts *B* that hold the magnet stand to the valve plate *C* are well insulated, and the valve-rod *D* is insulated at *E*, so that if a leak should develop in the insulation between the wire coils and this part of the magnet frame it would do no damage.

In Fig. 114 an insulating plate *D* separates the magnets from the plate *C*, and the bolts *B* are also insulated from it. The magnet rock-lever *B'* is insulated from the connecting-rod *C'* at the joint *E*. If the plate *C* is kept clean there is little danger of impairing the insulation *D*, because the surface surrounding the stuffing-box of the pilot valve is lower than that on which the magnets are mounted; there is also a drain-pipe to carry off any water that may escape from the stuffing-box, and if the surface is not covered with dust and lint, which would cause water to creep up by capillary attraction, the insulating plate *D* will remain dry. Holes are drilled through the

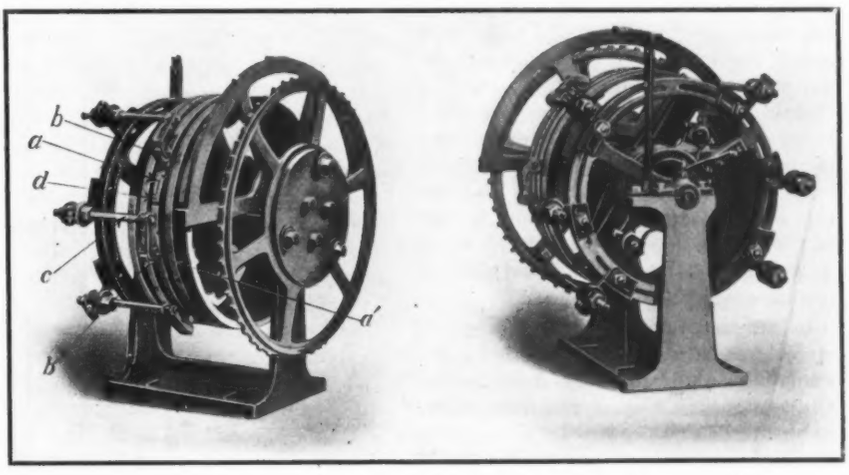


FIG. 112. TWO VIEWS OF FLOOR CONTROLLER

plate *C* for the bolts *B*, and other holes are drilled opposite the screws that hold the magnet cores to the base *A*. The position of each hole is shown in Fig. 115, *D D* being those through which the bolts *B* pass, and *E E E E* are the holes opposite the magnet-core screws. The latter holes permit the removal of the magnets without taking off the base plate *A*, Fig. 114. If it is desired to remove the magnets it is important to be sure that the current is turned off, as otherwise, if there should be a leak between the magnet coil and the core, the screw-driver coming in contact with the sides of the hole *E*, which it would be sure to do, would form a ground connection.

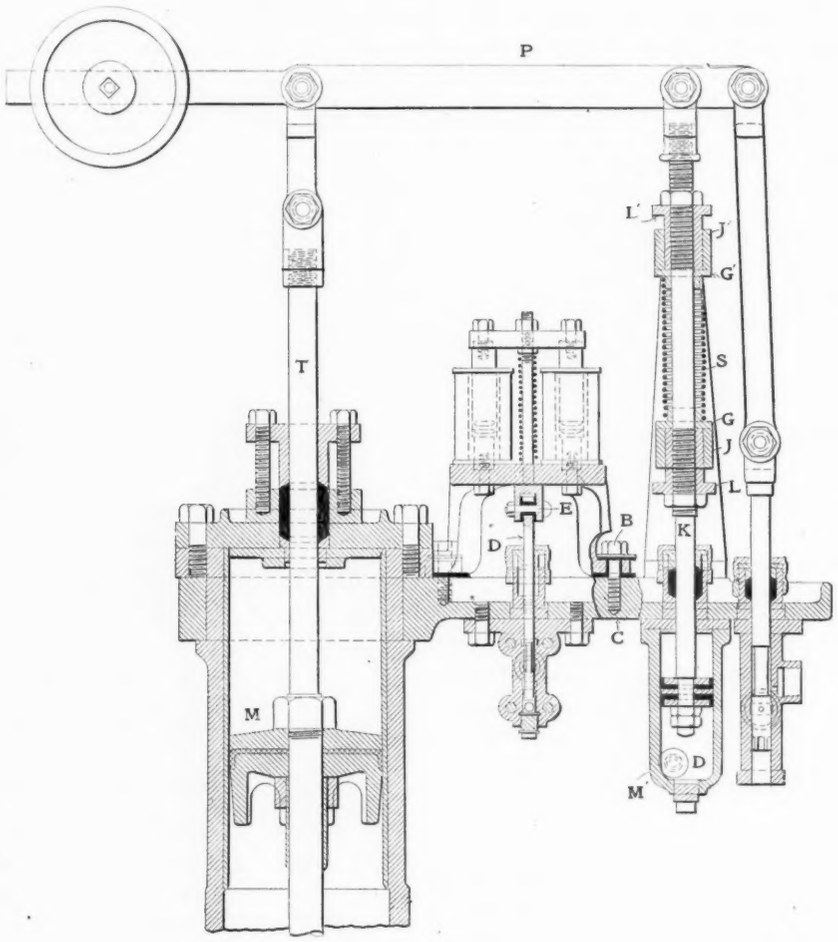


FIG. 113

In the construction shown in Fig. 113 there is as little liability of injuring the insulation around the bolts *B* as in Fig. 114, as the surface on which the stuffing-boxes are held is depressed. The outline of this depressed surface is shown in Fig. 116, which is a top view of the plate *C*. The bolts *B* (Fig. 113) are screwed into the holes *B*, which, as will be seen, are outside of the line *C* which forms the boundary of the depressed surface in the plate *C*.

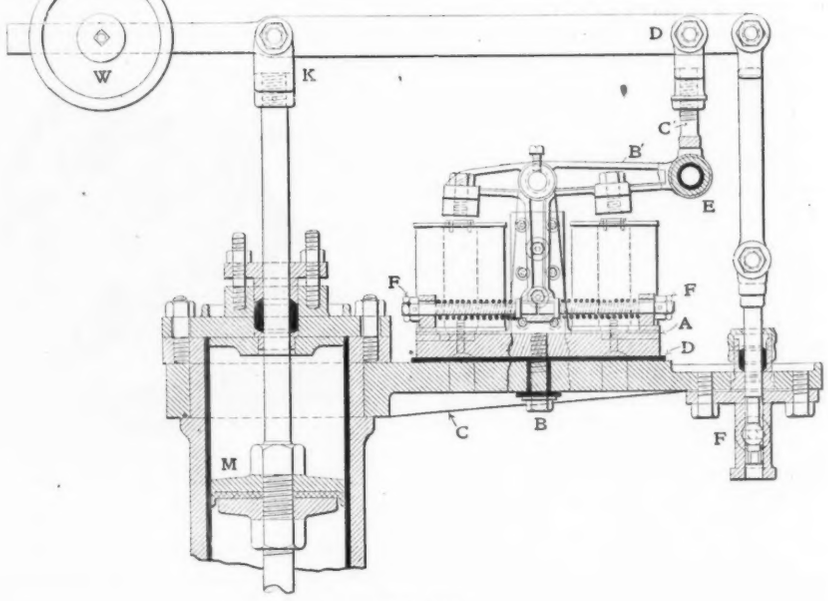


FIG. 114

Protection from Water

The only way that water can get onto the magnets in either Fig. 113 or Fig. 114 is by leaking out of the stuffing-boxes in sufficient quantity to form a spray. If this should happen, the best thing to do would be to put up a board, or a sheet of heavy cardboard or tin, to keep the water off until the stuffing-box is repacked. It is not a bad precaution to have galvanized-iron boxes made to permanently cover the magnets, not only to protect the coils from unexpected sprays of water from the stuffing-boxes but also to keep out dust.

The drain-pipe that connects with the depression in the valve plate *C*, Fig. 114, should be kept clear all the time, because the stuffing-boxes are sure to leak occasionally, and if the water cannot run off it will fill up the depression and reach the insulation *D*, Fig. 114, or that around the bolts *B*, Fig. 113. The strainers through which passes the water that enters the pilot valve should be cleaned out as often as may be necessary to insure free circulation of the water. If this is not done the main valve will not open as rapidly as it should, and the elevator car will not start up quickly enough. No definite directions can be given as to the frequency with which the strainers should be cleaned, as this depends entirely upon the amount of dirt in the water, and while once a week may be often enough in one case, once a day may be too seldom in others. About the best guide is in the operation of the elevator. If, within a certain time after the strainer has been cleaned, it is found that the starts are too sluggish on the down trip, the idle strainer should be tried and the effect noted. If this improves the starting, it indicates that the first strainer requires cleaning. After a few trials the length of time the strainers can be used without cleaning will be readily apparent. On the up trips of the car the condition of the strainers will not have any effect on the starting, because the pilot valve is then lifted and the water above the motor piston at the top of the main-valve cham-

ber escapes into the discharge pipe, the rapidity of discharge being controlled entirely by the opening through the pilot valve.

For Removing the Magnets

If at any time it should be desired to remove the magnets it can be done without disturbing the base plate or the frame in Fig. 113, and it is advisable not to remove the latter if the insulation is sound, because there is always a certain amount of uncertainty about securing per-

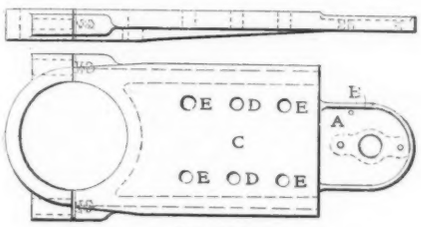


FIG. 115

fect insulation when the plate is replaced. In Fig. 113 it can be easily seen that the magnet coils and plungers may be removed by unscrewing the bolts that hold them to the frame, and the latter need not be removed unless it is desired to take out one of the valves *D*. In Fig. 114 the magnets can also be removed by taking out the screws through the holes in the valve plate *C*, as already explained. The lever *B'* can be removed by withdrawing the pin upon which it rocks, and this can be removed by loosening the set-screw shown in the drawing.

No part of the magnet apparatus shown in Fig. 113 requires lubricating, and this is equally true of Fig. 114, for although

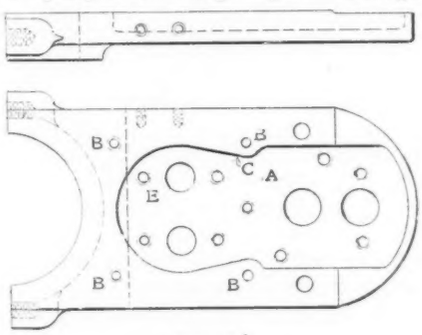


FIG. 116

the lever *B'* rocks on its supporting stud and there is a slight movement in the joint *E*, the total movement is so small that the parts can run dry practically as well as if lubricated. If it is felt that some lubrication is necessary, it will be sufficient to remove the pin and rub its surface well with a soft-lead pencil. It is not advisable to use oil or grease on these joints, because such lubricants spread over the surface and catch dust, increasing the danger of injuring the insulation. Oil itself, if clean, is a good insulator, but the particles of dust that stick to it are likely to be good conductors, also. All the bearings of the floor indicator should be properly lubricated, but it is not necessary to oil the rollers *b b* or strips *a a'*, Fig. 112.

Proper Treatment of Cables

The stationary cables *B*, *E*, *F*, Fig. 111, require no especial attention, as there is no reason why they should deteriorate, but they should be examined to ascertain if they are exposed where they are liable to be injured. If they are found to be improperly protected at any point they should be shielded without delay. The flexible cable *H*, from the junction *G* to the car, requires frequent inspection because the continuous bending will cause it to give out at some point sooner or later. If it is found to be chafed anywhere a thorough investigation will probably show that it rubs against the car or the wall of the elevator well, and an effort should at once be made to remedy the defect, either by changing the end fastenings so the cable may run free, or by covering any rough surfaces against which it strikes, or by both means. If the cable is improperly hung or protected, the insulating covering will soon be destroyed, and the wires may be broken so that the circuit connection with some of the floors cannot be completed, in which case the car will fail to respond to the manipulation of the push-buttons on these floors; or, two or more wires may come together and form a short-circuit which would put the elevator entirely out of service.

How to Locate the Pilot Valve

The proper adjustment of the pilot valve as regards location is of decided importance, as upon it will depend the position of the main valve when the elevator is at rest, and also the velocity of the car. In Fig. 113 the motor cylinder *M'* is so arranged that the ports at both ends are connected with the discharge pipe when the elevator is not running, hence the spring draws the piston-rod *K* to the central position when it forces the collars *G G'* against the collars *J J'*. From this it can be seen that if the sleeves *L L'* are raised, the motor piston *M* of the main valve will rest in a lower position when the pilot valve is central, because wherever the sleeves *L L'* may be set, they will be drawn to the central position, with reference to *J J'*, by the spring *S*, and as the elevator will not stop until the pilot valve is central, the shifting out of position due to the depression of *K* must be in the main valve. If the sleeves *L L'* are lowered, the displacement of the piston *M* will be in the opposite direction, that is, upward. The movement of *L L'* up or down from the position in which they are shown causes the piston in the cylinder *M'* to stop either higher or lower than shown, but it will be noticed that the cylinder is much longer than the stroke, to provide room for adjustment. The stroke of the piston in the cylinder *M'* is equal to the difference between the lengths of *L L'* and *J J'*. In Fig. 114 the adjustment of the position of the pilot valve is effected by means of the centering screws *F F*, and as will be seen the result is the same as in Fig. 113; that is, if the screws are adjusted so as to lift the joint *E*, the main valve will be raised, and if the adjustment depresses *E*, the piston *M* will be depressed, since the pilot valve must come to the central position to stop the elevator.

Adjustment to Regulate Speed

The effect produced by adjusting the

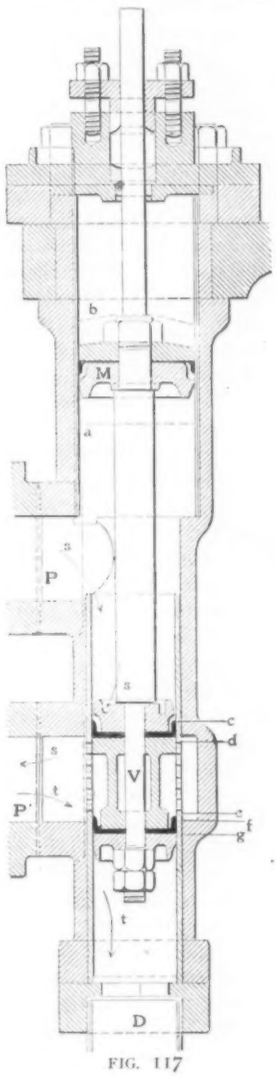


FIG. 117

pilot valve in the manner above explained can be understood readily from Fig. 117, which will be recognized as a vertical section of the main valve and chamber. It shows the lower valve *V* in the stop position, and it will be noticed that the cup packings lap over the ports considerably at both ends—from *c* to *d* at the upper end, and from *e* to *g* at bottom—hence the valve can be moved a distance equal to $c\,d + e\,g$, without setting the car in motion in either direction. This simply means that the motor piston *M* can be in any position between the dotted lines *a* and *b* when the car is stopped. When the elevator runs down no water is used; the weight of the car furnishes the mov-

ing force, and the water is forced out of the upper end of the cylinder, down the circulating pipe, through the valve chamber in the direction indicated by the arrows *s s s*, through as much of the port *P'* as may be uncovered by the valve *V*, and into the lower end of the cylinder. The flow of water is impeded slightly by the frictional resistance in passing through the circulating pipe, the valve chamber and other passages, but this is not enough to prevent it from running through quickly enough to cause the car to descend at a very high velocity, especially if heavily loaded. Furthermore, whatever this resistance may be, it will remain about the same for all trips. To permit the regulation of the speed of the car, by compensating for different loads, the valve *V* is opened more or less so that the main impediment to the free circulation of the water is the passage through the holes in the brass lining of the valve chamber, opposite the port *P'*. When the car runs up, the water in the lower end of the cylinder passes out through the port *P'* into the discharge pipe *D*, and the rapidity with which it can escape will depend on the amount of port uncovered by the valve *V*. From all this it is evident that if the car does not run fast enough on the down trip, its velocity can be increased by adjusting the pilot valve so the motor piston *M* will rest lower when in the stop position, which means that the end of the lever (*E*, Fig. 114) must be depressed, and the sleeves *L L'*, Fig. 113, must be raised. If this is done, the valve *V* can be moved farther down when running, so as to open the port *P'* wider, and thus permit the water to circulate more rapidly. In the same way, if the car ascends too slowly the speed may be increased by adjusting the pilot valve in the opposite direction.

This explanation of the adjustment of the pilot valve applies to car-lever control as well as to electromagnetic control. It may be well to mention, however, that the required increase in speed cannot always be obtained by pilot-valve adjustment. Thus, if the up speed is too slow and the down speed just right, then increasing the up speed will reduce the down speed. If the down speed is too slow, increasing it will reduce the up speed. In cases of this kind pilot-valve adjustment will do no good, as the cause of insufficient speed is lack of power, and the proper remedy is to increase the pressure in the pressure tank slightly. It is only when the car runs faster in one direction, as well as slower than is desirable in the other direction, that anything can be done by pilot-valve adjustment.

In 1912, from April 1 to October 31, inclusive, there will be held at Tokio, Japan, an international exposition which promises to be the largest ever held in that country. The Japanese government is actively fostering the movement.

The Cost of Power

By C. T. Wilkinson

Fundamental in all considerations dealing with the cost of power is a complete knowledge of the fuel resources of the country, together with the price, thermal value and composition of each fuel. Few people are more thoroughly in touch with this subject than the members of the staff of the technological branch of the United States Geological Survey. It is therefore considered that the accompanying comparative tabulations of estimated costs between a 600- and a 6000-horse-power station, which it was proposed to equip with either gas or steam apparatus, will be of interest. The table was prepared by Prof. R. H. Fernald, who is in charge of the experimental work of the Survey's gas-producer section.

COMPARATIVE TABLE OF ESTIMATED COSTS BETWEEN A 600- AND A 6000-HORSE-POWER STATION, GAS POWER AND STEAM.

	600 H.P.		6000 H.P.	
Size of plant				
Type of plant	Gas.	Steam.	Gas.	Steam.
Cost of plant	$48,000	$40,000	$420,000	$420,000
Service	300 days × 24 hours.		365 days × 24 hours.	
Load factor	75 % for 10 hours. 33⅓% for 14 hours.		75%	
Tons of coal and price	1,300 tons.	3,000 tons.	21,000 tons.	42,000 tons.
	$2.75 per gross ton.		$2 50 per gross ton.	
Gallons of oil and price	1,200 at 30 cents.		10,950 at 30 cents.	
Pounds of waste and price	2,000 at 7 cents.		5,000 at 7 cents.	
Engine-room labor and wages	2 engineers at $17 weekly.		1 chief engineer, $100 per mo. 3 ass't engineers, $17 weekly. 3 oilers, $12 weekly.	
Gas-house and boiler-room labor and wages	2 men at $15 week.		2 men at $60 per mo. 4 men at $45 per mo.	
Extra cleaning	$4.50 per week.			
Gallons water (price, 2 cents per M.)	18,000,000	125,000,000	246,000,000	1,500,000,000
Total cost of coal	$ 3,680	$ 8,250	$ 52,500	$105,000
Total cost of oil	360	360	3,285	3,285
Total cost of waste	140	140	350	350
Total cost of engine-room labor	1,768	1,768	5,720	5,720
Total cost of producer and boiler labor	1,560	1,560	3,600	3,600
Total cost of extra cleaning	234			
Total cost of water	360	2,500	4,920	30,000
Total operating expenses	$ 8,102	$14,578	$ 70,375	$147,955
Interest on investment	2,400	2,000	21,000	21,000
Depreciation, repairs, taxes, ins., etc.	5,760	4,800	50,400	50,400
Total operating cost and fixed charges	$16,262	$21,378	$141,775	$219,355
Total kilowatt-hours	1,550,000		26,000,000	
Cost per kilowatt-hour	$1.05	$1.38	$0.55	$0 85
Total saving per year by operating producer-gas plant	$5,116		$77,580	
Difference in first cost	$8,000			
Months required to pay difference, by saving in operating expenses	19			

These tabulations are not only impartial, but they also serve to show that the department is making valuable observations independently of the mere classification and analysis of fuels. Certain assumptions are made as follows: First, the engines, whether of the internal-combustion or steam type, are reciprocating. (Turbines are not considered.) Second, in the 600-horse-power plant only one unit was taken, while in the 6000-horse-power plant three units were assumed, each of 2000 horse-power capacity. Third, staff salaries are not considered.

An examination of the table will bring out certain points on which further information may be desired. For instance, it will be noted that the estimated cost per horse-power of the 600-horse-power steam plant is less than that of the 6000-horse-power plant. This is accounted for by the fact that in the small station entire simplicity was assumed (hand-fired boilers, for instance), and no conveyers nor economizers, superheaters, automatic stokers, etc., were allowed; whereas in the 6000-horse-power plant all these refinements were added. Both plants are to operate condensing.

With regard to the cost per horse-power of the gas plant, it may be stated that equal completeness of apparatus was assumed in both cases, which resulted in a reduction from $48 to $42 per horse-power first cost.

With regard to operating expenses, it will be noticed at once that the item, "Depreciation, repairs, taxes, insurance, etc.," is higher for the steam station than for the gas station in the smaller plant, while in the large plant they are the same; and in this connection it may be stated that although a very small amount of data is available for this item, yet such information as could be obtained led to the belief that this was an entirely satisfactory allowance. In both gas-engine plants, scrubbers and cleaners and all refinements are allowed for.

In examining tables of this character, it must be remembered that much depends upon local conditions and that this tabulation is only intended to deal with a general case. For example, the price of coal given might be taken exception to; but it will vary in each locality. Further, the gas-engine plant might very readily use a lower grade of fuel than that used by the steam plant, which would lead to yet greater economy in its favor.

A Noteworthy, Small Steam Plant

By J. E. Kent

Following is a description of a small steam plant in western Michigan, which is moderate in cost, maintenance and operation expense. This plant furnishes power for a brickyard and is a mild surprise to visitors, for the reason that brick plants are usually equipped with "any old thing" which will do the work, and economy is rarely considered.

The plant contains two 150-horse-power water-tube boilers, with shaking grates; one 44-inch by 90-foot steel stack; one 14x36-inch Corliss engine; one jet condenser; one 10x8x10-inch duplex fire pump; one 6x4x6-inch duplex boiler feed-pump; one 5x3½x5-inch duplex pump, and receiver, one 4x2½x3-inch simple duplex pump. The engine has a heavy-duty frame and is of the single-eccentric type. Two eccentrics would be an advantage in this case, as the engine runs condensing and difficulty is experienced in getting a proper valve setting. The chief engineer compensated for this somewhat by cutting new keyways in the valve-stems and bell-cranks on the inlet valves, and by so doing changed the angle between the wrist-plate and the point of valve opening. The engine runs 10 hours per day, while the boiler plant is in commission 24 hours daily except Sunday, because of the continuous demand for steam for the driers.

The condenser maintains a vacuum of about 26 inches at all times. The discharge from the condenser is carried to a hight above that of the regulating valve on the feed-water heater and the make-up water for the heater is taken by gravity from this pipe. No trouble from oil has been encountered in spite of the fact that the exhaust pipe from the engine to the condenser contains no oil separator. The condenser is piped to run either condensing or to exhaust into the feed-water heater, as the engineer wishes.

The small duplex pump takes the condensation from the brick driers and returns it directly to the boilers. This pump, as well as the boiler feed-pump, exhausts directly into the feed-water heater. The pressure carried on the driers ranges between 30 pounds during the day to 45 pounds at night, and the returns come back at a very high temperature. This pressure is regulated by means of a 4-inch reducing and regulating valve which takes steam at the boiler pressure of 125 pounds.

The fire pump is not piped to the heater but exhausts directly to the atmosphere, because this pump is used for only a short time each day to fill the tank. This tank is depended upon to furnish water for the entire works and for the feed-water heater at such times when the engine and condenser are shut down, and at night. The feed-water heater is constructed of steel plate, and besides eliminating all oil from and conserving a large part of the exhaust steam by condensation, it heats the feed-water to within 5 or 6 degrees of the boiling point at all times and gives partial purification of the raw water as well. The exhaust steam condensed within the heater will approximate one-tenth of the total volume the heater handles. The writer prefers a heater built of cast iron for the reason that the cast-iron plates are thicker than steel plates and are not as susceptible to corrosion and pitting caused by the carbonic-acid gas liberated from the water. The simple pump is used for pumping crude oil to the kilns.

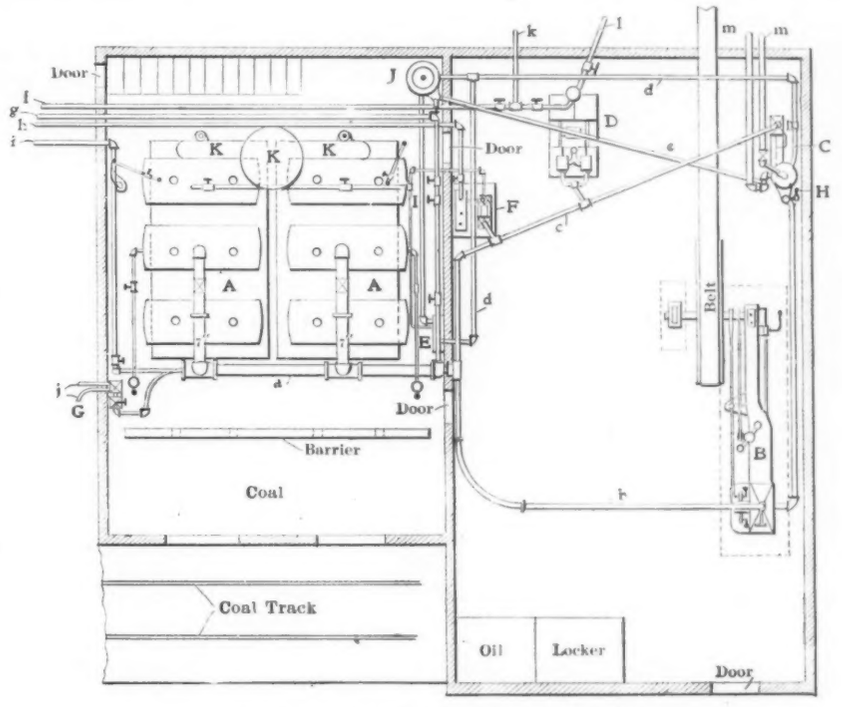
High-pressure material is used on all live-steam piping, long bends being used between the boilers and the engine and long-sweep fittings on all other live-steam pipes, as well as on the discharge from the fire pump. All live-steam lines are covered with sectional covering. A 3-inch line goes to the kiln shed to furnish live steam for the crude-oil burners with which the brick are burned.

The accompanying rough sketch will give an idea of the lay-out of the plant. At *A A* are the boilers; at *B* is the engine, at *C* the condenser (atmospheric valve at *H*), at *D* the fire pump, at *E* the boiler feed-pump, at *G* the oil pump, at *I* the reducing valve, at *J* the feed-water heater; at *K K K* are the stack and breeching, at *a, b, c* the leader and steam lines to the engine and pumps, at *d d* the exhaust to the heater; at *e* is the water supply pipe from the condenser to the heater; at *f, g, h, i,* respectively, are the cold-water line from the tank, live-steam pipe to the driers, return pipe from the driers and the live-steam line to the kiln shed; at *j* are the suction and discharge from the oil pump; at *k* is the fire line from the fire pump, at *l* the suction to the fire pump; and at *m m* are the intake and discharge from the condenser.

This plant formerly used two tubular boilers and a high-speed engine. The new boilers take up more room than the old ones did and are therefore set somewhat close to the side walls of the boiler room. The engine room, however, is very commodious and is very well lighted. The floor level is about 15 feet below the level of the surrounding ground. This makes possible the use of bottom-dump coal cars.

Hand-firing is used and the firemen have no trouble in preventing black smoke from issuing from the stack. The boilers are loaded somewhat below their rated capacity, a good grade of steam lump coal is used, and the load is fairly steady. The pressure on the driers being raised at 6 o'clock each evening the driers take as much extra steam at night as the engine uses during the day, thus the boiler load is constant. From 7 to 8½ tons of coal are burned to manufacture about 45,000 brick per day. This includes steam used for drying. While a kiln is being burned it requires about 2 tons more per 24 hours. The brick manufactured are standard building brick, both red and white.

Crude oil is used under the kilns and is burned by means of hydrocarbon burners of a special type designed and patented by the company's chief engineer. Crude oil was formerly used under the tubular boilers but at prevailing Michigan prices it costs more per actual horse-power output than coal. With the system in use at



LAY-OUT OF STEAM PLANT FOR A BRICKYARD

this plant the oil does not require preheating, but is pumped cold directly to the kiln shed. The oil is stored in a cement-lined brick tank which is built into the ground and is vented to the open air. Electricity for lighting is purchased, because installing a generating unit would hardly be profitable, as the machinery is not operated at night, and during the winter months everything is shut down.

Improvised Air Valves for Water Lines

By Frank Martin

In some pumping plants considerable difficulty is experienced with air and other gases in the water, caused by leaks, defective suction lines, etc. Assuming that the air cannot be kept out of the lines, owing to continuous duty, or unwillingness to rebuild, the question as to how to get it out is important, as it is detrimental to the boilers, causes the pumps much trouble and is otherwise objectionable.

Having tried many forms of common radiator air valves without success, and finding that the cheapest heavy air valve would cost too much, albeit we required something strong, durable and easily taken apart and repaired, I set about to devise a float valve that could be quickly assembled, and most of the parts for which could be bought in ordinary supply stores. I decided to make the valve with a vertical tubular float, having a cast-steel valve and brass stem, and designed to be easily reground, and, without making drawings, purchased the materials for the various parts shown grouped in Fig. 1. Starting with the ⅛-inch plug, I drilled a hole through the center lengthwise with a No. 52 drill (0.063 inch diameter), and counterbored this hole ⅛ of an inch from the taper side of the plug. Next, the 1-inch nipple was tested for inside clearance, the burs being first removed and the ends made square and true, after which the brass tube was tried in the nipple, to make sure that it would slip through easily. The ends of the tube were then straightened and the thickness reduced to about 28 B. & S. gage (= 0.012 inch), and one end was turned inside for a depth of about 3/16 of an inch, the solder being first wiped out with a cloth.

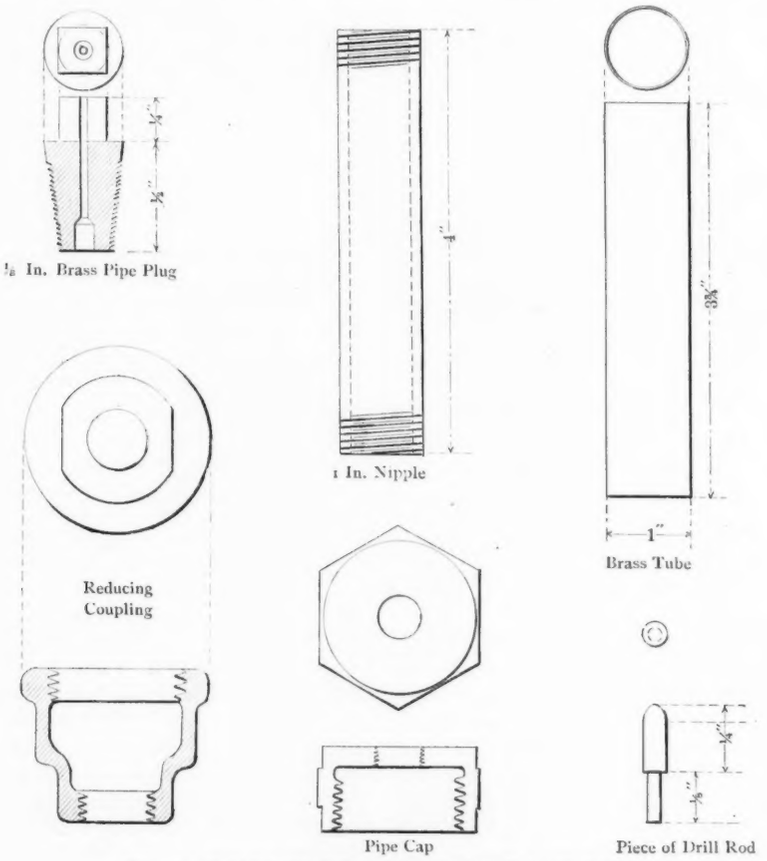


FIG. 1. DETAILS OF PARTS FOR IMPROVISED AIR VALVE

The piece of drill rod was then chucked and the diameter for a distance of ⅛ inch on one end was reduced to about 0.067 of an inch. The other end was rounded off very carefully to a radius 0.034 of an inch (one-half the diameter), making the end semi-spherical. Two sides of the bead on the small end of the reducing coupling were filed flat to accommodate a wrench. An 11/32-inch hole was drilled though the center of the cap and tapped from the outside with a ⅛-inch iron-pipe tap, care being taken to fit the plug so that it would enter to about half the length of the thread. Then the brass rod was trued in a lathe so that it fitted the bore of the brass tube snugly, and a groove 1/16 of an inch deep was turned in the end of the rod. An axial hole was drilled through the end as shown in Fig. 2 with a No.

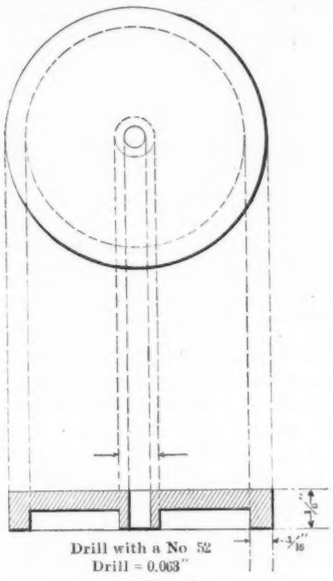


FIG. 2.

52 drill, and the piece was smoothed and cut off to finish up ⅛ of an inch long. The pin was driven in the center hole from the plain side. Then the outer edge was tinned, the excess solder wiped from the edge of the disk, and the disk was fitted into the tinned end of the brass tube, carefully alined and sweat into place over a small frame.

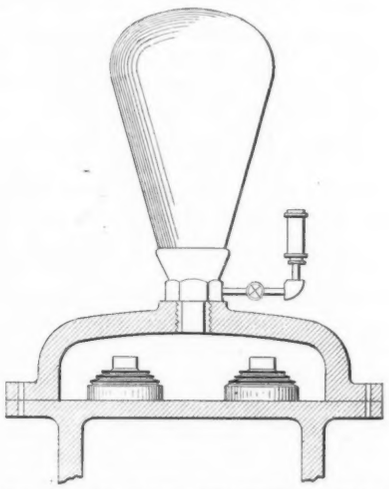


FIG. 3. AIR VALVE ATTACHED TO PUMP

Finally the 1-inch nipple was screwed tightly into the reducing coupling, the float was dropped inside, with the steel pin upward, and the cap (with the ⅛-inch plug in it) was screwed on finger tight, so it could be seen how the pin lined up with the center of the plug. When it was found to be in the middle, so that it moved freely, the float and plug were removed and the pin was

ground into the seat of the plug with oil and flour emery, by turning the parts upon each other while holding them in line. When seated, the parts were permanently assembled and tested with water pressure.

Why and How It Works

The area of the hole in the plug equals $0.063 \times 0.063 \times 0.78 = 0.003096$ square inch. If 75 pounds pressure per square inch is used, the pressure on the valve seat will be $0.003096 \times 75 = 0.2322$ pound, and when the float is lifted by water into the seat this pressure will lift the float into place and keep the valve closed. Supposing that the water is displaced by air, the float weighing 6.5 ounces (= 0.406 pound), the float will fall, its weight being more than the force applied to keep it in place, and this will let the air out. This does not take into consideration how much force is present and exerted by the bouyancy of the float, nor have we considered the changes taking place inside the float by reason of the change of air volume owing to compression; and, of course, there is a point at which the float will sink if the pressure is raised high enough, like the "little devil in the bottle" of our boyhood days, called the Cartesian diver.

In designing floats for high pressure, therefore, due regard must be taken to keep the weight of the float in excess of the pressure exerted on the valve area, closing the bottom of the float, if necessary, to keep its displacement high.

This valve will be found useful in filling closed tanks, economizers and hot-water heating systems, in operating pumps, and for water in pipes under pressure and water radiation for all kinds of elevator plungers. It will work on any pressure below 75 pounds down to a pressure that multiplied by the area of the opening equals the weight of the float. Fig. 3 shows one of these valves attached to a pump.

A New Engineering Society

A new engineering society has been organized in Philadelphia, called the Engineers' and Constructors' Club.

Membership in this society is limited to the engineers composing the organization of Dodge & Day. Its object is to discuss subjects relating to engineering and construction and to give all members the benefit of the experience gained by each in his particular line of work.

The proceedings of the club, giving the papers presented and the discussions, will be published regularly.

The officers of the club are president, Harold T. Moore; secretary, George Walters; managers, F. C. Andrews, H. F. Sanville, John E. Zimmermann, C. N. Lauer.

How Does Altitude Affect Steam-engine Power and Economy?

By Otto H. Mueller

Some people have a notion that with a low barometer the production of a vacuum ought to be easier, others that the engine drops off in power, and still others that it loses in economy. As to vacuum, the general custom, although a bad one, is to call for a vacuum of such a per cent. of the atmospheric pressure. In marine installations, if a manufacturer of condensers, who without difficulty obtains 90 per cent. vacuum with his apparatus, guarantees the same percentage for a location where the average reading of the barometer is only 24 inches, he might encounter serious trouble, as the absolute pressure which he has to maintain in the condenser is reduced in the same proportion as the atmospheric pressure.

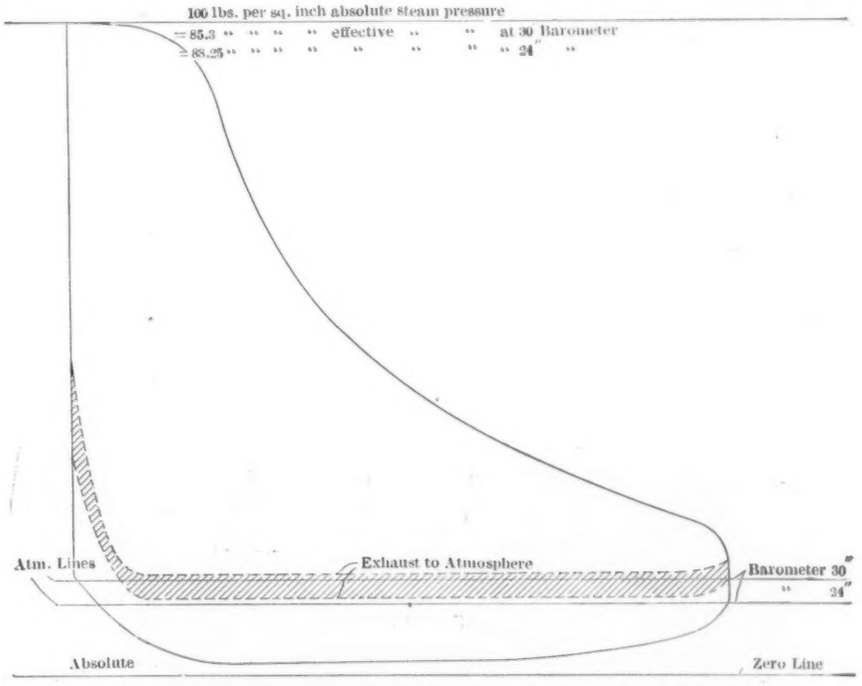

100 lbs. per sq. inch absolute steam pressure
= 85.3 " " " " effective " " at 30 Barometer
= 88.25 " " " " " " " " 24 "
Atm. Lines
Exhaust to Atmosphere
Barometer 30"
" 24"
Absolute
Zero Line

DIAGRAM SHOWING EFFECT OF ALTITUDE ON POWER AND ECONOMY

Assuming the cooling water to be supplied at 70 degrees Fahrenheit in either case, then at 30 inches barometer, when the remaining absolute pressure is 3 inches, the temperature to be maintained in the condenser must not exceed 114 degrees Fahrenheit, according to Regnault's tables; and the cooling water will have to be discharged at a lower temperature, depending on the design of the condenser, say at 100 degrees Fahrenheit. The increase of temperature being 30 degrees, 34 pounds of cooling water will be required for each pound of steam condensed. But with a barometer reading of 24 inches, the absolute pressure at 90 per cent. vacuum is only 2.4 inches. The temperature of saturated steam of this pressure is 106 degrees, and allowing the same difference of 14 degrees the cooling water must not exceed 92 degrees Fahrenheit, and the quantity required for each pound of steam condensed will be 46 pounds, or 35 per cent., more than in the former case. The air pump, of course, must also be much increased in size.

With the same proportion of cooling water and the same condensing apparatus only the same absolute pressure can be maintained, whatever the standing of the barometer. The power required for the water will also remain the same, but that for the air pump will decrease in proportion to the atmospheric pressure. Any confusion of this kind could be avoided by dropping the term of "vacuum" altogether and using "absolute pressure" instead.

As to power and economy, the accompanying diagram is explanatory. It is drawn for an absolute initial pressure of 100 pounds per square inch. Steam of this pressure has the same temperature and requires the same amount of heat to be generated from water of a given temperature under any altitude or standing of the barometer. It corresponds to an effective pressure of 85.3 pounds per square inch with the barometer at 30 inches, and of 88.25 pounds per square inch with the barometer at 24 inches, but this makes no difference, except a slight one in the strain to which the boiler plates are subjected.

From the diagram it is seen that the atmospheric line changes its position between the zero line and the initial steam-pressure line, but the diagram itself, for exhaust into a condenser, remains unchanged. The same applies, of course, to the economy, hence there is no reason

to give any other feed-water guarantees for an engine to be erected at a high altitude.

The non-condensing engine, however, gains in power when the barometer is low, the difference between the barometer reading of 30 and 24 inches being represented by the shaded portion of the diagram. This gain is only possible because in this case the steam does not work in a closed cycle. It is partly compensated by the drop of economy which takes place when the exhaust steam is used for heating the feed-water, inasmuch as with a barometer of 24 inches the water cannot be heated higher than 200 degrees Fahrenheit. The slight increase of power to pump the feed-water into the boiler is also to be put against the gain in power, and so is the loss caused by the steam not reaching the same pressure at the end of compression, whereby the clearance is less filled up with steam. But all these losses are small compared with the gain in the mean effective pressure on the piston.

Catechism of Electricity—XXVIII

Portable Wattmeters

548. *For what is a wattmeter used?*

To measure the power (in watts) being supplied to a circuit, for which purpose a portable indicating wattmeter is used.

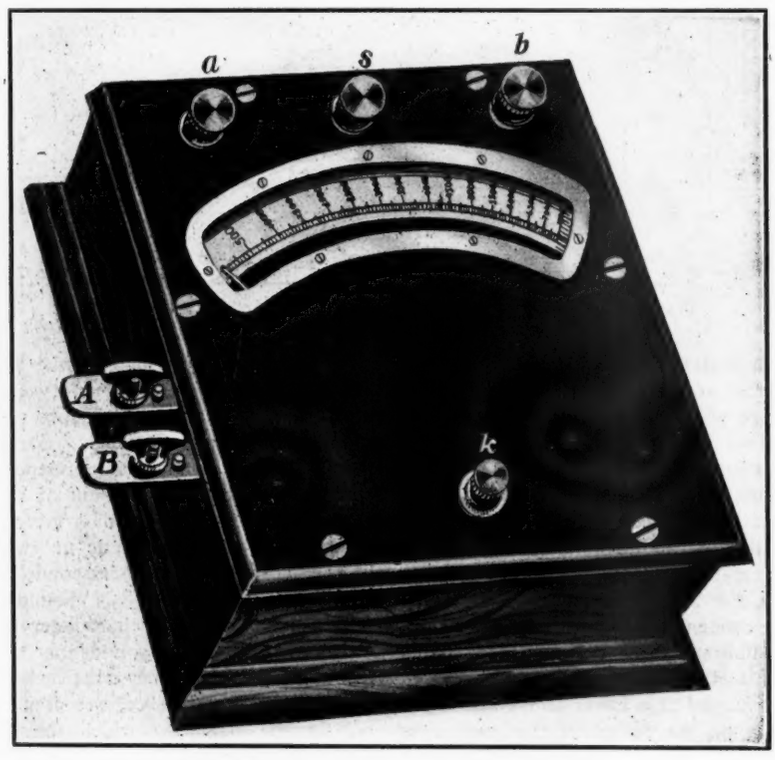


FIG. 138. PORTABLE INDICATING WATTMETER

549. *Show a portable indicating wattmeter and describe its construction.*

A portable indicating wattmeter depending for its operation upon the magnetic action exerted between movable and fixed coils is shown in Fig. 138, and a diagram of its construction and connections is given in Fig. 139. Corresponding parts in both illustrations are lettered alike. In all cases when the current and voltage are taken from the same circuit, *A* and *B* are the current terminals, and *a* and *b* the pressure terminals. This case is represented in Fig. 139, where *T* is an alternator supplying current to the circuit in which *x y* represents a resistance or load, such as lamps or motors. If, now, it be desired to measure the power in watts

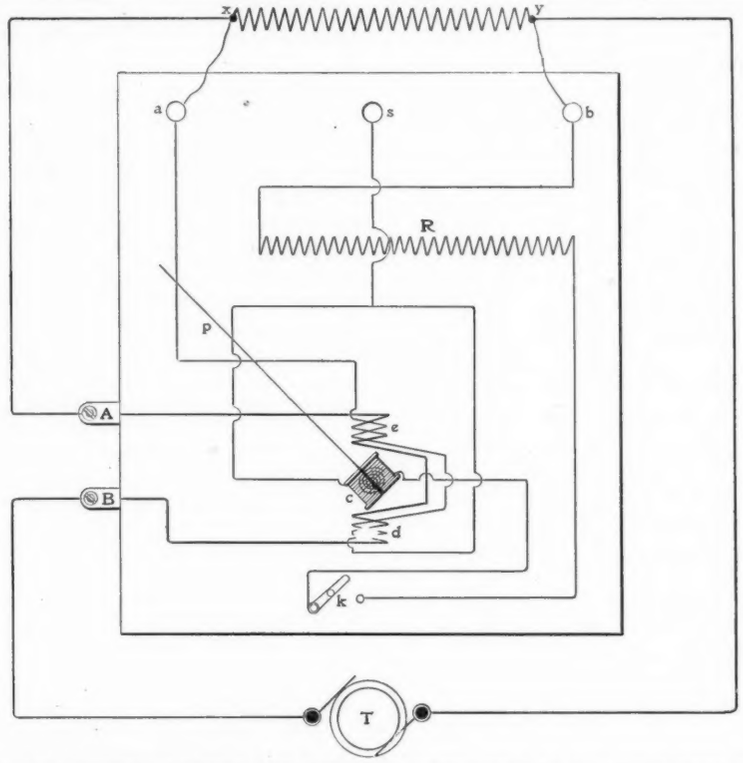


FIG. 139. INTERIOR CIRCUITS AND EXTERNAL CONNECTIONS OF THE INDICATING WATTMETER SHOWN IN FIG. 138

supplied to the circuit *x y*, the wattmeter is connected as shown, the pressure coils represented by the light ziz-zag lines at *e d* being connected to the same side of the load *x y*, as are the corresponding current coils represented by the heavy ziz-zag lines at *e d;* this method of connection is followed to avoid a high potential difference between the coils.

550. *How does this form of wattmeter operate?*

Supposing the current enters at *B*, passes around the current coils *d* and *e* in opposite directions and out at *A*. In the pressure circuit the current at the same instant enters at *a*, passes down the fine wire, around the coils *e* and *d* in the opposite direction to the former current (the wire of the two sets of coils being wound in opposite directions), and then passes through the movable coil *c*, the key *k* and the resistance *R*, leaving the instrument at *b*. The two circuits through the coils *e* and *d* are wound in opposite directions in order to neutralize the deflection which would be caused by the potential coil *c* if the load circuit *x y* were opened. If it were not for this differential winding there would be a deflection representing a number of watts, but as no power would be suplied to the circuit *x y*, and as it is intended the instrument should measure only the power actually transmitted, any deflection of the coil *c*, and consequently of the pointer *p*, would be incorrect.

551. *For what purpose is the binding post s, Figs. 138 and 139, employed?*

When it is necessary to measure current and pressure supplied from independent circuits, as in calibrating the wattmeter, using constant current and varying potential—or, as is sometimes desirable, in transformer tests—the voltage should be applied to *s* and *b* instead of *a* and *b*. The differential winding is then cut out of circuit. This case is illustrated in Fig. 140.

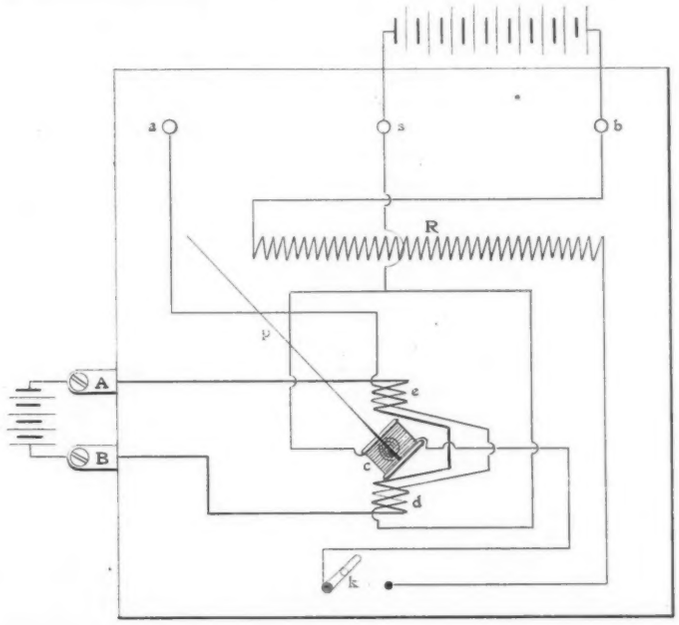


FIG. 140. CONNECTIONS OF THE INDICATING WATTMETER FOR MEASURING CURRENT AND PRESSURE FROM INDEPENDENT CIRCUITS

552. *Are portable wattmeters made in any other form than that shown in Fig. 138?*

Yes, another very common type of portable wattmeter is that shown in Fig. 141. This meter operates by reason of the magnetic attraction between the inclined coil *c* and an oblong piece *a* of soft sheet iron mounted on a spindle to which the pointer *e* is also attached. The reader will recognize this construction as similar to that in the inclined coil meters already shown and described, and consequently will understand the operating of this meter without further explanation.

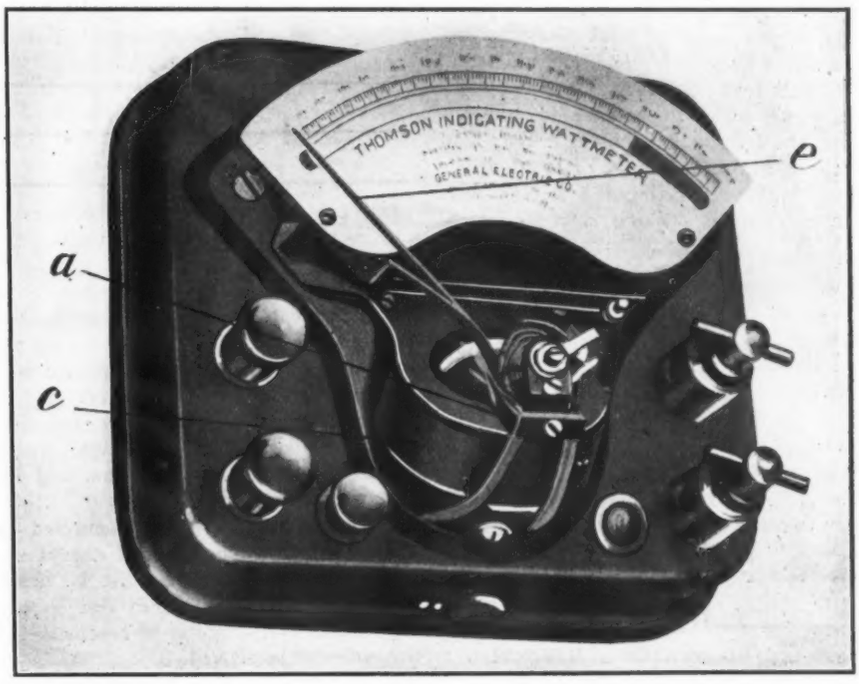


FIG. 141. AN INCLINED COIL INDICATING WATTMETER

Stationary Wattmeters

553. *Show the working parts of a stationary wattmeter and explain their operation.*

A stationary recording wattmeter (so-called) for alternating- or direct-current two-wire circuits is shown, with outer case removed, in Fig. 142. The diagram of wiring in this meter and the connections with the outside circuit are shown separately in Fig. 143. In Fig. 142, *w z* represents the iron support for the instrument; *f f* is a metal frame containing the upper bearing of the armature *c*. The armature corresponds to the movable coil *c* in the portable wattmeter, Fig. 139. The armature *c* in this meter, however, is provided with a brass commutator to which the coils in the armature are electrically connected. This arrangement, capable of revolving in the field formed by the coils *d* and *e*, which are connected together in series, constitutes a small electric motor, the number of revolutions of its armature in a given time depending upon the number of watts in the circuit in which it is connected. The shaft *t* of the armature of the motor being connected to a recording tachometer or speed indicator, *m*, automatically registers the number of revolutions which equals the number of watt-hours. The watt-hours, or the quantity of electricity which has flowed, are read directly from the dials of the instrument, which is, therefore, a watt-hour meter, not merely a wattmeter. Attached to the lower end of the armature shaft is a metallic plate *h* which revolves in the two permanent magnets *k* and *l* when the armature turns. The rotation of the plate develops in itself induced currents, which make it a sort of electric generator acting upon itself in a closed circuit. The plate, therefore, serves as a brake to damp the revolutions, keeping the speed more uniform.

The action of the meter when connected for service on circuits carrying between 50 and 600 volts, and 3 to 50 amperes, is as follows: The current entering at *A*, Fig. 143, passes around the field coils *d* and *e* in opposite directions, and out at *B;* or *vice versa*. In the pressure circuit, the current enters at *b*, passes through the resistance *R* to the commutator *r*, contact with which is made through strips of copper pressing against it on opposite sides. After entering the left side of the commutator, it passes through the coils of the armature *c*, and out again at the right-hand side of the commutator, then through the shunt *s* and out at *A;* or *vice versa*. The shunt *s* consists of an adjustable resistance coil mounted within the field coil *d*, Fig. 142.

A sheet-iron case completely covers the working parts when in service, thus preventing injury and the entrance of dust, and, at the same time, allows the dials of the speed indicator to be read through a glass window in the upper part of the case firmly around the meter.

554. *For what purpose is the shunt s, Figs. 142 and 143, employed?*

It is used to compensate for the fric-

tion of the moving parts, which is increased by deposits of dust in time. Unless this shunt is employed it is necessary to clean the commutator and in other respects restore the meter to its initial condition periodically, in order to secure the

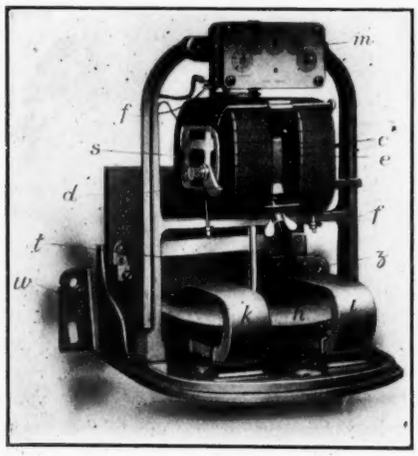


FIG. 142. STATIONARY RECORDING WATT-HOUR METER, WITH CASE REMOVED

highest degree of accuracy in operation. The friction effect, however, becomes practically constant after a comparatively brief period of use. Beyond this stage, friction increases but little, and, if instead of cleaning the commutator and restoring it to its initial condition, compensation is made for the increased friction, the meter will, except under unusual conditions, remain in a permanent condition and retain its light-load accuracy. The adjustable shunt makes it possible to compensate for friction and obtain a light-load accuracy through a range of 10 to 20 per cent., without affecting the meter's general calibration. That is, a meter which,

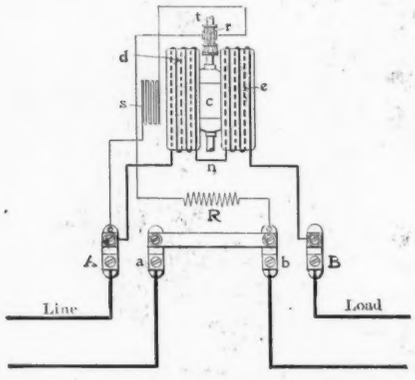


FIG. 143. CONNECTIONS OF A RECORDING WATT-HOUR METER TO A TWO-WIRE CIRCUIT

after a period of use, may run from 5 to 10 per cent. slow at light load, may be adjusted to normal accuracy in a few minutes by means of the shunt, without moving the meter or even disconnecting it from the service wires.

555. *Can the power supplied to both sides of a three-wire circuit be recorded simultaneously on a single watt-hour meter?*

If the wiring and connections on a recording watt-hour meter be made as shown in Fig. 144, the energy supplied to both sides of a three-wire installation will be recorded upon a single dial.

556. *What precautions are necessary to observe in installing or caring for a recording watt-hour meter?*

The meter should be mounted vertically in a dry place which is not subject to heavy vibrations. Screws should be used in fastening the meter to its support. A small spirit-level mounted on the base of the instrument will be found convenient in leveling the meter. If the conditions are such that the meter will be subjected to more or less vibrations, it is advisable to place a number of soft-rubber washers under the heads of the screws which bind the meter to the wall and between the meter and the wall itself.

House meters should be installed between the line switch and the load. In

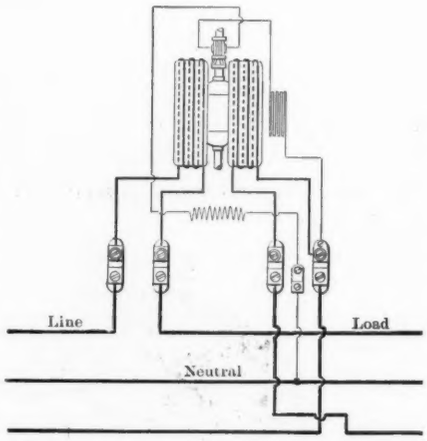


FIG. 144. CONNECTIONS OF A RECORDING WATT-HOUR METER TO A THREE-WIRE CIRCUIT

motor installations they should be located between the line switch and the motor switch, so that the meter armature will always be excited and the effects of repeated heating and cooling avoided. In motor installations this arrangement prevents the inductive kick from burning out the meter armature.

If the meter is properly connected in circuit, the plate or disk will always rotate to the right. Care must be taken never to allow the shaft to rest on the jewel until everything is in readiness for the meter to be started.

Just before starting, it is advisable to turn the armature gently about twenty times while pressing the brushes lightly against the commutator. This precaution will usually prevent the sparking due to dust collected during shipment; but if it does not, insert between the brushes and the commutator a piece of ¼-inch cotton tape which is free from lint and draw it gently back and forth, at the same time rotating the shaft slowly. While doing this it is important not to spring the brushes out of their original position.

The tension of the brushes is carefully adjusted before leaving the factory and should not be changed unless the meter is to be installed where considerable vibration exists. Under such circumstances the tension can be slightly increased, in order to avoid sparking due to vibration, which impairs the accuracy of the meter.

Oil must not be used in the top bearing under any circumstances. If the registering movement is oiled it must be carefully wiped afterward so that no oil will run down on the commutator. Oil or dust on the commutator will cause the meter to register less than the correct number of watt-hours. It is important to see that the disk and armaure move freely and that no dirt collects on the magnets in such a way as to touch the disk.

A Home-made Thermometer

By A. Heaton.

It would seem at first thought that meteorology is a subject which has no connection with the generation or conservation of steam energy, but on reflection it will be seen that natural thermic and barometric conditions either assist or retard those artificially produced in a measure proportional to their extreme changes. For illustration, consider the vast sums which are paid out for more or less non-conductive substances to counteract those external effects. Again, if a locomotive will haul a given train in August with a certain amount of coal, we do not expect it to haul the same train with the same quantity of coal in January.

There are also many engines at the sea level which maintain a vacuum of 27 inches, and there is a Westinghouse-Parsons turbine in my city which shows as high as 29¼ inches on a mercury vacuum gage; on days when the barometer is high it will go as high as 29¾; and a high vacuum in a turbine installation represents money, lots of it.

But because these things are done near the sea level it does not follow that they could be also done at the summit of the Himalayas, nor even up among the Rocky mountains, for, approximately, water boils at 1 degree Fahrenheit less for every 596 additional feet of altitude, so that at the sumit of the Himalayas, the highest attainable vacuum would be less than 11 inches.

The maximum and minimum registering thermometer here illustrated consists of a circular box *A*, Fig. 1, 1½ inches diameter and ⅝ inch deep, with a nurled screw-cap and a flange for screwing the device to the north side of a building. Into a boss on the box are screwed or pinned

two 22-foot lengths of iron ⅛-inch gas pipe which run through a series of guide supports *B* and are made fast in the cross tail-piece *C*. A 22-foot length of brass ⅛-inch pipe is made fast in the tail-piece between the two iron pipes, but runs free at the other end, entering with a reduced diameter through a dust-proof stuffing-box; it is attached to a 5/16-inch crank on

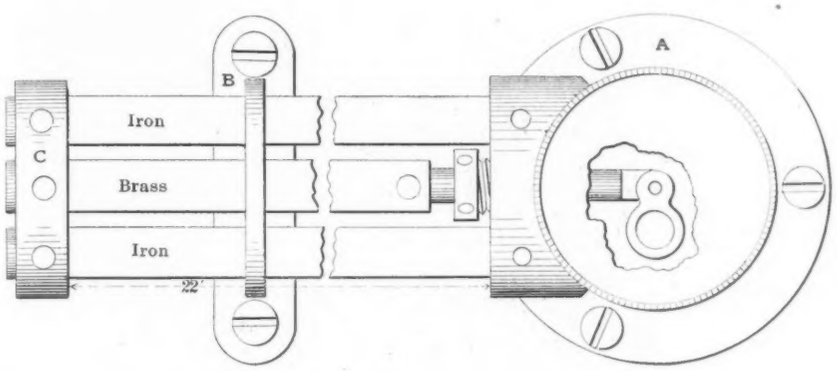


FIG. 1. CONSTRUCTION OF MAXIMUM AND MINIMUM REGISTERING THERMOMETER

a ⅜-inch shaft which goes through to the inside of the building, and it carries a pointer 18 inches long, which extends downward to a graduated brass arc, Fig. 2. On this arc are two sides which the pointer pushes along and leaves at the extreme limits of its travel.

With this thermometer it is not necessary to go outside to get the outside record, but simply take the record from the slides once in 24 hours and push them back against the pointer for the next day's record. With metals of average

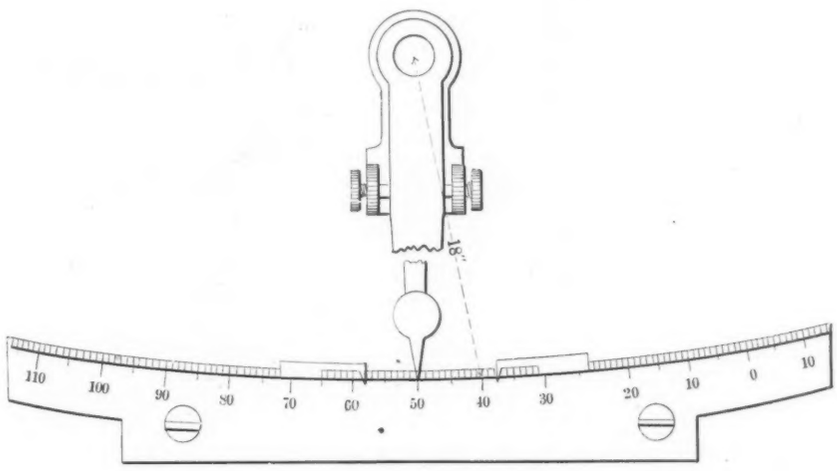


FIG. 2. POINTER AND GRADUATED BRASS ARC OF THERMOMETER

density, the differential expansion between brass and iron will give with 22-foot tubes and a 5/16x18-inch indicator an approximate travel on the dial of 1/20 inch per degree Fahrenheit, but as all metals vary in density, it is safer to calibrate from a reliable mercury thermometer.

Direct-current Wiring for Lighting Circuits

By N. A. Carle

In selecting the size of the wiring for lighting circuits it is necessary to consider the number, candle-power and efficiency of the lamps, the voltage and length of the circuit and the allowable voltage loss. The usual lamps installed are 16-candle-power on 52-, 110- and 220-volt circuits. The average 52- and 110-volt lamps should show an economy of 3.5 watts per candle-power and the 220-volt lamps should not exceed an average of 4 watts per candle-power.

The voltage loss is usually expressed as a percentage of the voltage at the switchboard. The voltage at the center of distribution of the lamps should be that for which the lamps are designed and the switchboard voltage should be high enough to give this amount. There will be a discrepancy in the voltage at lamps located on either side of the center of distribution, but this method gives the best balance to the system.

The distance from the assumed initial point, such as the switchboard, to the center of distribution of the lamps multiplied by two gives the whole length of the circuit.

The size of the wire is expressed by the formula:

$$c.m. = \frac{10.7 \times I \times L}{E},$$

where

$c.m.$ = Area of cross-section of wire in circular mils,
I = Current in amperes,
L = Whole length of circuit,
10.7 = Average ohms resistance of one foot of copper wire having a cross-section of one circular mil.

The chart on page 756 is designed to enable one to read directly the size of wire to be used for either open or concealed work for any system of 16-candle-power lamps up to the number of 200, and for circuits of 52, 110 and 220 volts, with lengths of circuits of from 50 to 1000 feet, and for actual drop in volts up to 15, or up to 10 per cent. of the switchboard voltage loss. While the inductance of alternating-current circuits increases the drop in volts, the increase is usually so small as to be negligible.

Example

If a lamp installation is to consist of one hundred 16-candle-power lamps on a 110-volt circuit having a total length of 350 feet, what size of wire will carry this current with a drop of 5 per cent. of the switchboard voltage, and will that size of wire be satisfactory for a conduit installation?

Starting with 100 "Number of 16 C. P. Lamps," read across to 110 "Voltage of Lamps," then drop a vertical line from this point across the lines representing the "Size of Wire." Then starting with 5 "Per cent. Volts Lost" read across to 110 "Voltage Delivered at Lamps," then down to 350-feet "Whole Length of Circuit," then across to the intersection of this line with the vertical line mentioned above which would give the proper size of wire as No. 5. This intersection comes within the Fire Underwriters' limit line for concealed work, so that this size is proper for conduit installation.

It is to be noted that if no restriction is placed on the amount of drop, for open work a No. 7 wire could be used with a 7.7 per cent. voltage loss at the switchboard.

The Fiske street plant of the Chicago Edison Company, described in our issue of December, 1906, is the handsomest and most substantial steam plant ever built, and yet, says W. L. R. Emmet, in a paper read at the Washington meeting of the National Electric Light Association, if the units were assigned ratings equivalent to those of other prime movers, its cost per kilowatt would unquestionably be the lowest that has been produced.

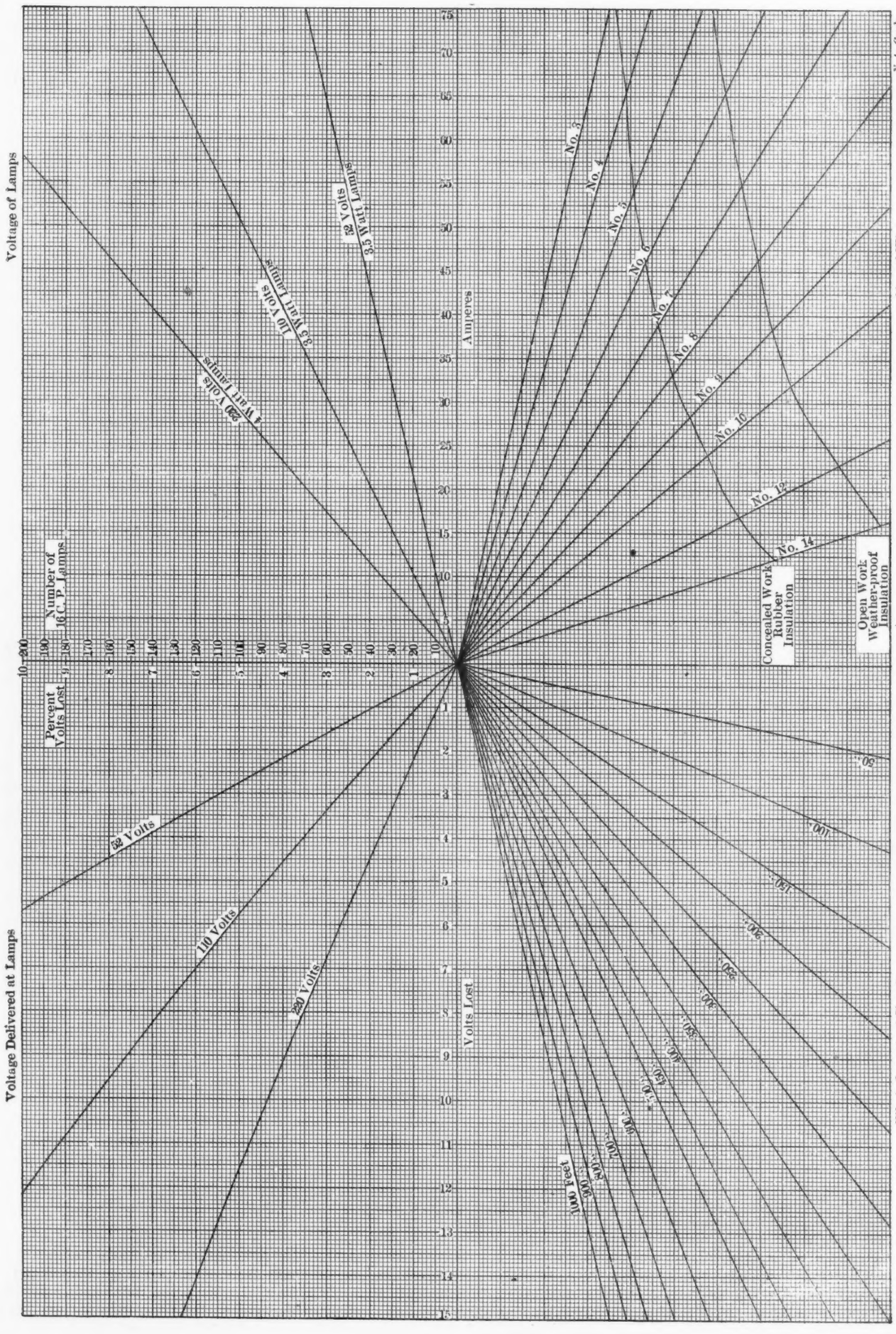


DIAGRAM FOR CALCULATING WIRING FOR LIGHTING CIRCUITS

A New Development in Air Compressors*

A Machine that at Constant Speed Automatically Varies the Volume of Air Delivered to Meet the Constantly Fluctuating Demand

BY FREDERICK A. HALSEY

The driving of air compressors by electric motors has introduced a new problem into air-compressor design. A fundamental feature of air-compressor service is that the consumption of air is variable between wide limits, and the delivery of the air by the compressor must meet this condition—a substantially constant pressure being maintained while the volume of air delivered is such as to maintain this constant pressure under a constantly fluctuating consumption. With compressors having independent steam engines the requirements are naturally and usually met by varying the speed of the compressor, but with motor-driven machines this method of regulation becomes impracticable and other expedients must be resorted to, among such expedients being the use of unloading devices by which the action of the compressor is entirely suspended from time to time, and the more recent device of throttling the suction of the machine. Motor-driven compressors are now called for in considerable numbers of large sizes, and the problem is of growing importance. The machines here shown were made by the Nordberg Manufacturing Company, the one shown in Fig. 1 being for the Atkiebolget Maskiniffar, Sweden, while the one from which the indicator cards were taken was made for the North Butte Mining Company. This latter machine has cylinders of 22 and 36 by 42 inches, and a normal capacity of 3500 cubic feet of free air per minute.

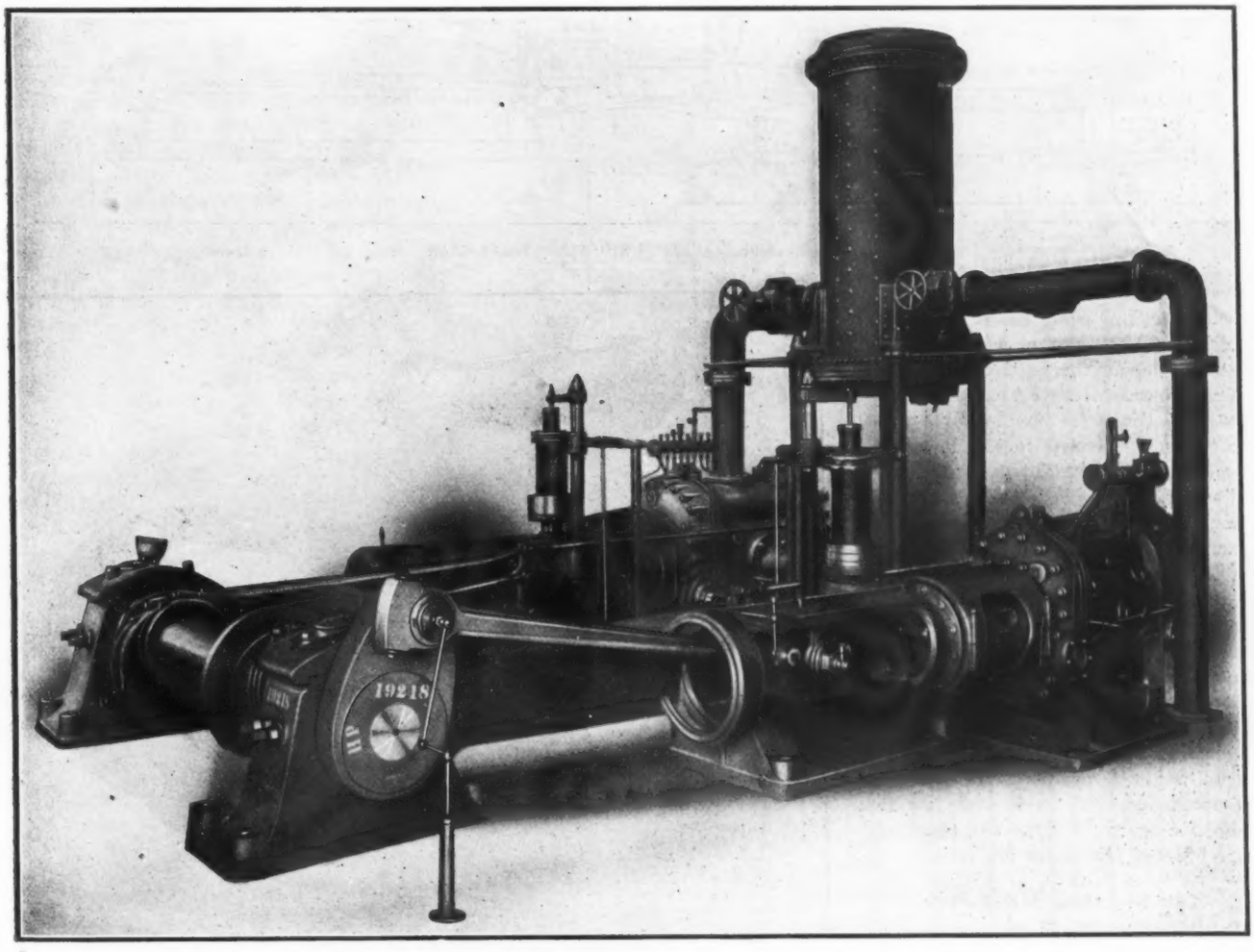


FIG. 1. THE NORDBERG CONSTANT-SPEED VARIABLE-DELIVERY AIR COMPRESSOR

The Principle of the Machine

The desired result is here obtained by closing the inlet valve before the stroke is completed, the air in the cylinder being then expanded below atmospheric pressure during the remainder of the stroke and compressed again during the return or compression stroke, the result being, in effect, to vary the working length of the stroke as required, the delivery of air being varied in the same ratio, while, except for possible leakage of the valves and piston, no loss is involved in the process. The valves are of the Corliss pattern

*From the *American Machinist* August 22, 1907.

actuated by the regular Nordberg full-stroke gear, the closing being a dash-pot, as in steam-engine practice, and controlled by a pressure governor, making the machine entirely automatic.

The Valve-gear

Fig. 1 is from a photograph of the machine, taken with the machine standing on the erecting-shop floor, and shows its general appearance. Fig. 2 is a side view of one of the cylinders, taken from between the frames, and shows clearly the general construction of the valve-gear. The wrist-plate is driven by the reach-rod *a*, while the releasing gear is driven by the rod *b*, which oscillates the arm *c* about the fixed center *d*.

The two reach-rods *e f* to the releasing cams, are connected to the three-armed rocker *g h i*, swiveled to the lower end of *c*, *i* being connected by the link *j* to the radius fork *k* to which the pressure governor *l* is connected. It is obvious that under the action of the eccentric-rod the parallelogram of parts *c i j* k will oscillate as such, the arms *g h* maintaining a vertical position and giving equal movement to both knock-off cams. Should, however, the pressure governor draw arm *i* upward, *g h* will be inclined to the left and the parts will, as before, oscillate as a parallelogram, *g h* swinging in its inclined position but maintaining parallelism with itself while the two ends have again the same movement and the release of the valves is altered.

The Releasing Mechanism

The releasing gear is another beautiful piece of mechanism and is clearly shown in Fig. 3. The main-valve moving piece has three arms *a*, *b* and *c*, the wrist-plate link being connected to *a*, the releasing latch *d* to *b*, and the governor-cam arm *e* to *c*. The governor-cam arm is connected to the governor by the rod *f* and has thus a compound motion—one by which it swings bodily about its swivel-pin at the top, and another by which it is adjusted laterally by the governor. The cam arm at its lower end is composed of two circular arcs struck from the center above, the two arcs being connected by a short incline. The roller at the end of arm *g*, which is keyed to the releasing latch, rides within the cam groove as arm *g* swings under the action of the main eccentric and releases and engages the latch as the roller passes the jog in the cam groove—the position of the release being determined by the governor as already explained.

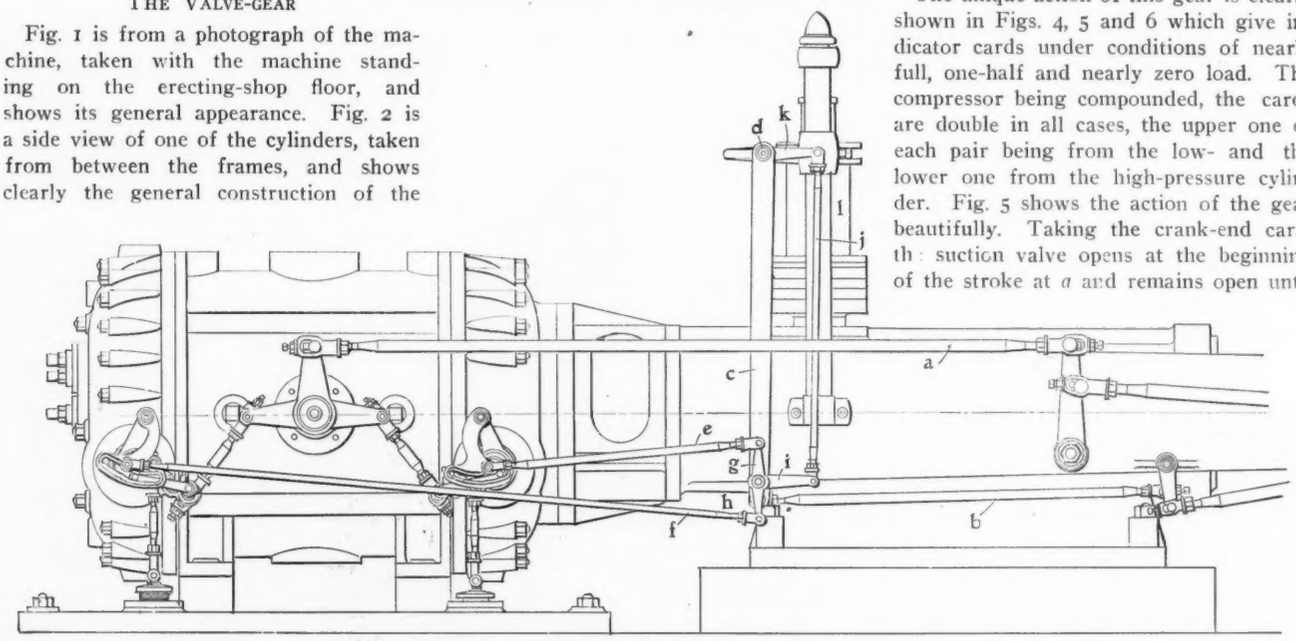


FIG. 2. SIDE ELEVATION SHOWING VALVE-GEAR

Indicator Cards

The unique action of this gear is clearly shown in Figs. 4, 5 and 6 which give indicator cards under conditions of nearly full, one-half and nearly zero load. The compressor being compounded, the cards are double in all cases, the upper one of each pair being from the low- and the lower one from the high-pressure cylinder. Fig. 5 shows the action of the gear beautifully. Taking the crank-end card, the suction valve opens at the beginning of the stroke at *a* and remains open until

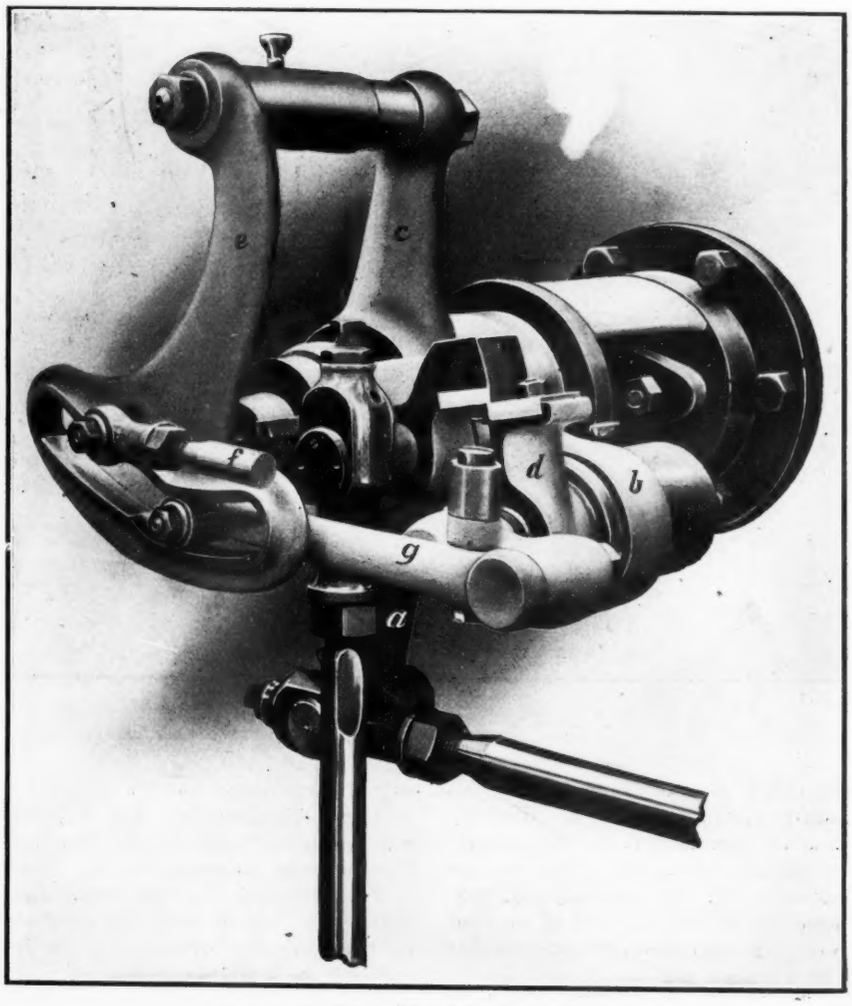


FIG. 3. THE NORDBERG FULL-STROKE VALVE-GEAR

mid-stroke is reached, when at *b* the releasing gear acts and the valve is closed. From *b* to *c* the air contained in the cylinder expands until at *c*, when the end of the stroke is reached, compression begins—the expansion and compression lines being practically superimposed until atmospheric pressure is reached, when the compression proceeds in the usual manner. The action of the high-pressure valves is precisely similar, except that the expansion and re-compression of the air is from the receiver pressure instead of from the atmosphere. The action will be seen to be precisely the same as that of steam-cylinder admission valves, opening at the end of the stroke and closing at a point determined by the governor.

In order to overcome mechanical difficulties each cylinder is provided with its own governor, and the perfection of action of these governors will be seen at once from the figures attached to the cards, giving the intercooler and receiver pressures, the extreme variation of the latter being but three pounds.

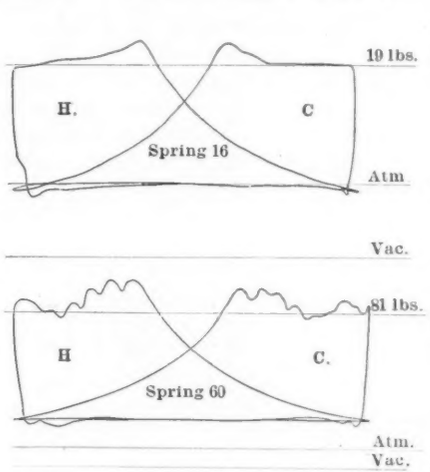


FIG. 4. NEARLY FULL LOAD

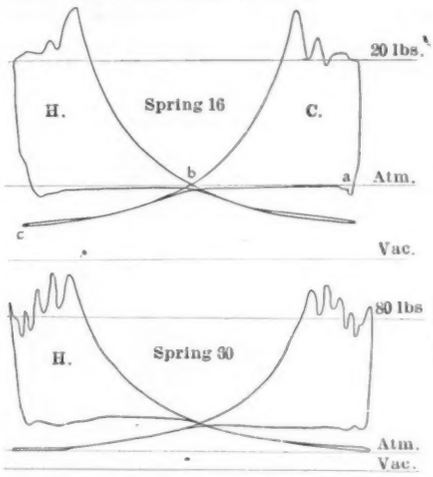


FIG. 5. HALF LOAD

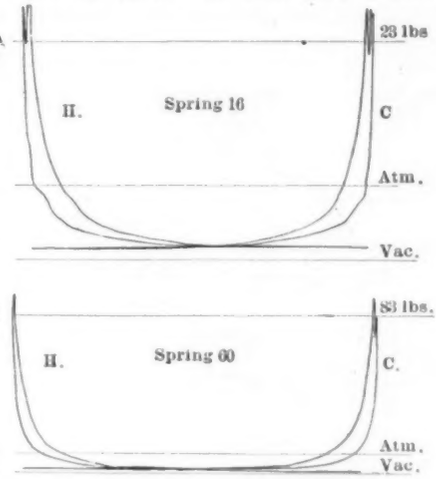


FIG. 6. NEARLY ZERO LOAD

INDICATOR CARDS. SPEED 74 REVOLUTIONS PER MINUTE

THE VALVES

Fig. 7 gives a section of a cylinder-head and its valve. The inlet valve is shown

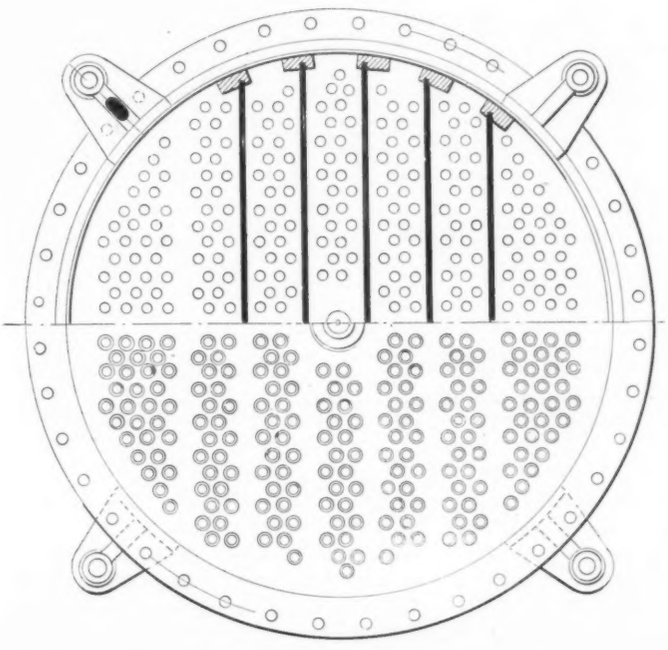


FIG. 8. PLAN SECTION

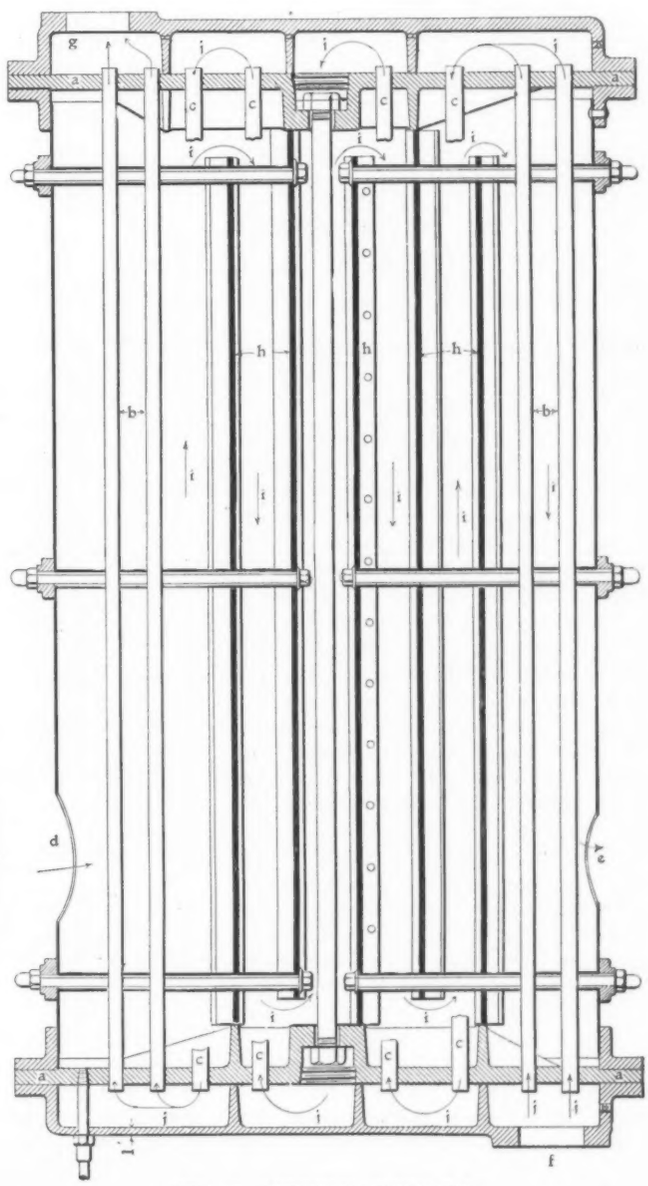


FIG. 9. SECTIONAL ELEVATION

THE NORDBERG INTERCOOLER

as open, the closing movement being by a turn to the right. When closed the port *a* opens into the main port entering the cylinder, and whatever be the pressure within the cylinder, the same pressure is maintained behind the valve, which is thus prevented from lifting from its seat

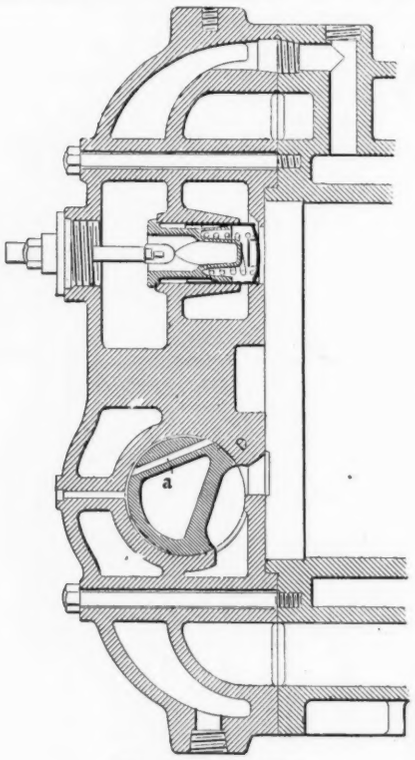


FIG. 7. THE VALVES

which, without this provision, might be the case.

The Intercooler

Figs. 8 and 9 show Mr. Nordberg's latest pattern of intercooler, in which nothing has been spared to insure perfect cooling. The economy of compound compression depends entirely upon the performance of the intercooler—many compound compressors being the reverse of economical because of the imperfect action of the intercooler. The margin of gain due to compounding is not large in any event, and with some inevitable loss due to the forcing of the air through two extra sets of valves, this margin may more than disappear unless the intercooler performs its function properly, and reduces the air to very nearly its original temperature. The flow of the water and air in opposite directions through the intercooler in order that the air at exit may have the advantage of the coolest incoming water is common, but I have never before seen so complete a provision to compel the water to flow equally through all of the tubes, and thus insure that all parts of the cooling surface shall be equally effective. The tube-plates are shown at *a a*, while complete tubes are shown at *b b* and others—cut off to avoid confusion—are shown at *c c*. The air enters the intercooler at *d* and is discharged at *e*, while the water enters at *f* and is discharged at *g*. Baffle-plates *h h h* guide the air in the manner indicated by the arrows *i i i*, while baffles in the water heads insure the flow of the water in the opposite direction as indicated by the arrows *j j j*.

Efficiency of the Machine

The efficiency of the compressor is indicated by the diagram, Fig. 10, in which the line for the actual indicated horse-power has been taken directly from the cards shown in Figs. 4, 5 and 6. The line for the theoretical indicated horse-power is based on the assumption of adiabatic compression in each cylinder, with perfect cooling between the cylinders and no valve loss—perfect intercooling being understood to mean the reduction of the air to its initial temperature when entering the low-pressure cylinder. The ratio between the two horse-powers is called the efficiency of compression and is shown in the efficiency curve at the top of the diagrams, this curve extending from an output of a little over 200 to one of 3600 cubic feet per minute. The curve will be seen to be remarkably high, and especially so for the smaller loads.

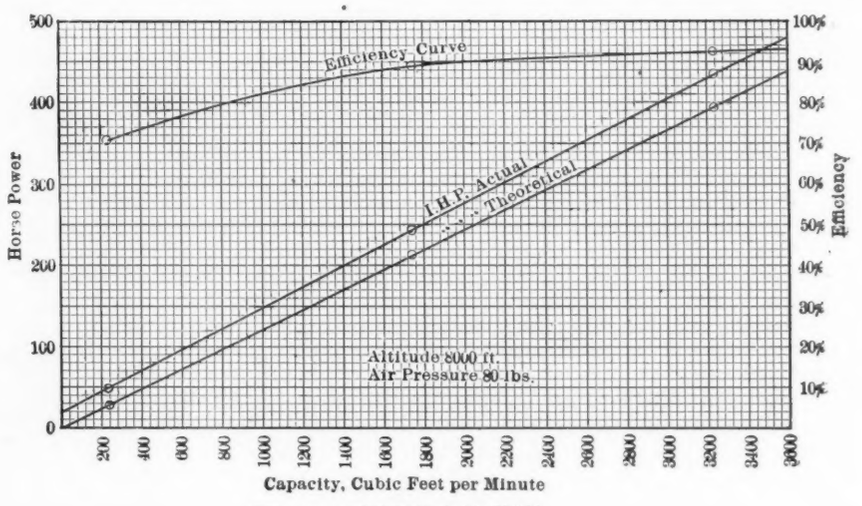


FIG. 10. EFFICIENCY DIAGRAM

The Combustion of Fuels

The accompanying tables will be found to save a good deal of tedious calculation in working out computations relating to the combustion of fuels. Table 1 gives the quantity of air required for the combustion of one pound of each of the solids or gases specified at the heads of the columns, if all of the oxygen were brought into contact with the molecules of the fuel and the latter were burned completely. It also gives the low and high values of heat liberated, the low value being that heat which is available when the latent heat in the water vapor cannot be utilized and the high value being the total heat liberated, including that in the water vapor. The values in the table are given to an unnecessary number of decimal places for the satisfaction of those who insist on very precise computation. All practical purposes will be served, however, by using not more than two decimal places.

TABLE 1. COMBUSTION OF ONE POUND OF FUEL.

Reduced to 14.7 Pounds Absolute Pressure and 32 Degrees Fahrenheit Temperature.

Fuel.	Carbon, C	Hydrogen, H	Methane, CH_4	Ethylene, C_2H_4	Carbon Monoxide, CO	Sulphur, S
Lbs. oxygen	2.6667	8.0	4 0	3.4286	0.5714	1.0
Lbs. air	11.5942	34.7826	17 3913	14.9068	2.4845	4.35
Cu.ft. air*	143.617	430.852	215.426	184.651	30.776	53.883
B.t.u., low	14.500.0	51,804.0	21,592.8	19,834.2	4,395.6	.....
B.t.u., high	14.500.0	61,524.0	24,021.0	21,222.0	4,395.6	.....
Products of Combustion.						
H_2O Pounds	.....	9.0	2.25	1.2857	.....	.....
H_2O Cu.ft.†	.....	179.3	44.82	25.614	.....	.....
N Pounds	8 9275	26.7826	13 3913	11 4783	1.9131	3.35
N Cu.ft.*	114 004	335.672	171.007	146.578	24.43	42.77
CO_2 Pounds	3 6667	.....	2.75	3.1428	1.5714	.....
CO_2 Cu.ft.*	29 89	.....	22.418	25.6201	12.81	.....
SO_2 Pounds	.....	.....	.....	.....	.....	2.0
SO_2 Cu.ft. (vapor)	.....	.....	.....	.....	.....	7.69

*Cubic feet at any other temperature, the pressure remaining unchanged, are equal to the cubic feet at 32 degrees multiplied by the constant in Table 3 corresponding to the other temperature.

†Hypothetical volume for 32 degrees temperature. The water vapor is at 212 degrees, unless superheated, and its volume is 1.263 times the hypothetical volume in the table.

TABLE 2. VOLUME AND WEIGHT OF GASES AT ATMOSPHERIC PRESSURE AND 32 DEGREES FAHRENHEIT.

Lbs.	Cubic Feet of Gas.						
	H	CH_4	C_2H_4	CO	CO_2	N	O
1	178 93	22 429	12.805	12.81	8.152	12.77	11.209
2	357.86	44.858	25 610	25.62	16 304	25.54	22.418
3	536.79	67.287	38.415	38.43	24.456	38.31	33.627
4	715.72	89.716	51.22	51 24	32.61	51.08	44.836
5	894.65	112.145	64.025	64.05	40.76	63 85	56.045
6	1,073.59	134.574	76.83	76 86	48 91	76.62	67.254
7	1,252.52	157.0	89.635	89 67	57 064	89.39	78.463
8	1,431.45	179.43	102.44	102.48	65.22	102.16	89.672
9	1,610.38	201.86	115.245	115 29	73.37	114.93	100 881
Cu.Ft.	**Pounds of Gas.**						
	H	CH_4	C_2H_4	CO	CO_2	N	O
1	0.005589	0 04458	0.07809	0.07806	0.12267	0.07831	0.08921
2	0.011177	0 08917	0 15619	0.15613	0.24534	0.15662	0 17843
3	0.016766	0.13376	0.23428	0.23419	0.36801	0.23493	0.26764
4	0.022355	0 178 4	0 31238	0.31226	0.49068	0 31323	0.35686
5	0.027944	0.22293	0.39047	0.39032	0.61335	0.39154	0.44607
6	0.033532	0.26751	0.46857	0.46838	0.73602	0.46985	0.53528
7	0.039121	0.31210	0.54666	0.54645	0 85868	0.54816	0.62450
8	0.044710	0 35668	0.62476	0.62451	0 98135	0.62647	0.71371
9	0.050299	0.40127	0.70285	0.70268	1.10402	0.70478	0 80293

Sulphur, of course is not a fuel, but it is a constituent in some solid fuels, and takes some of the oxygen from the air supplied for combustion; hence it is included. The useful heat of combustion is small and the proportion of sulphur in fuels is also relatively small; consequently, the heat due to combustion is generally ignored.

Table 2 gives cubic feet of gases for whole numbers of pounds and pounds of gases for whole numbers of cubic feet, at 32 degrees, Fahrenheit. In order to derive the volume or weight at some other temperature, it is only necessary to multiply the volume or divide the weight by the proper constant taken from Table 3.

Table 3 is of sufficient scope to cover boiler flue gases and gas-engine exhaust gases, under the most wasteful and most economical conditions ordinarily found in practice.

Example 1

A boiler furnace grate has a surface of 56 square feet, and is expected to burn Pocahontas coal at the rate of 20 pounds per hour per square foot. The coal contains by weight 85 per cent. of carbon, 5 per cent. of hydrogen, 3.5 per cent. of oxygen, 0.8 per cent. of nitrogen, 0.7 per cent. of sulphur and 5 per cent. of ash. How much air is required theoretically, for combustion, and how much heat will be liberated per hour? The temperature of the firing room is 80 degrees, Fahrenheit.

Answer

The quantity of coal is $56 \times 20 = 1120$ pounds per hour. This contains

$0.85 \times 1120 = 952$ pounds of carbon,
$0.05 \times 1120 = 56$ pounds of hydrogen,
$0.035 \times 1120 = 39.2$ pounds of oxygen,
$0.08 \times 1120 = 89.6$ pounds of nitrogen,
$0.07 \times 1120 = 78.4$ pounds of sulphur,
$0.05 \times 1120 = 56$ pounds of ash.

The oxygen is combined with $39.2 \div 8 = 4.9$ pounds of hydrogen, forming water vapor, leaving 51.1 pounds of hydrogen requiring air for combustion. The cubic feet of air required, reduced to 32 degrees temperature, will be

$952 \times 143.62 = 136{,}727$ cubic feet for carbon,
$51.1 \times 430.85 = 22{,}016$ cubic feet for hydrogen,
$78.4 \times 53.88 = 4{,}224$ cubic feet for sulphur.

Total = 162,967 cubic feet of air.

At 80 degrees temperature, the 162,967 cubic feet of air will have expanded to

$162{,}967 \times 1.09772 = 178{,}892$ cubic feet,

which is the quantity theoretically required per hour. The actual quantity is usually about twice the quantity ascertained by calculation because of the impossibility of bringing every atom of oxy-

TABLE 3. EXPANSION CONSTANTS FOR PERFECT GASES AT CONSTANT PRESSURE.

Formula: $\text{Constant} = \frac{\text{Temp.} + 459.2}{491.2}$

Temp.	Constant	Temp.	Constant	Temp.	Constant	Temp.	Constant	Temp.	Constant
1	0.93689	61	1.05904	121	1.18119	305	1.55578	610	2.17671
2	0.93893	62	1.06107	122	1.18322	310	1.56596	620	2.19707
3	0.94096	63	1.06311	123	1.18526	315	1.57614	630	2.21743
4	0.94300	64	1.06515	124	1.18730	320	1.58632	640	2.23779
5	0.94503	65	1.06718	125	1.18933	325	1.59650	650	2.25814
6	0.94707	66	1.06922	126	1.19137	330	1.60668	660	2.27850
7	0.94910	67	1.07125	127	1.19340	335	1.61686	670	2.29886
8	0.95114	68	1.07239	128	1.19544	340	1.62704	680	2.31922
9	0.95318	69	1.07533	129	1.19748	345	1.63722	690	2.33958
10	0.95521	70	1.07736	130	1.19951	350	1.64739	700	2.35994
11	0.95725	71	1.07940	131	1.20155	355	1.65757	710	2.38029
12	0.95928	72	1.08143	132	1.20358	360	1.66775	720	2.40065
13	0.96132	73	1.08347	133	1.20562	365	1.67793	730	2.42101
14	0.96335	74	1.08550	134	1.20765	370	1.68811	740	2.44137
15	0.96539	75	1.08754	135	1.20969	375	1.69829	750	2.46173
16	0.96743	76	1.08958	136	1.21173	380	1.70847	760	2.48208
17	0.96946	77	1.09161	137	1.21376	385	1.71865	770	2.50244
18	0.97150	78	1.09365	138	1.21580	390	1.72883	780	2.52280
19	0.97353	79	1.09568	139	1.21783	395	1.73901	790	2.54316
20	0.97557	80	1.09772	140	1.21987	400	1.74919	800	2.56352
21	0.97761	81	1.09976	141	1.22191	405	1.75936	810	2.58388
22	0.97964	82	1.10179	142	1.22394	410	1.76954	820	2.60423
23	0.98168	83	1.10383	143	1.22598	415	1.77972	830	2.62459
24	0.98371	84	1.10586	144	1.22801	420	1.78990	840	2.64495
25	0.98575	85	1.10790	145	1.23005	425	1.80008	850	2.66531
26	0.98778	86	1.10993	146	1.23208	430	1.81026	860	2.68567
27	0.98982	87	1.11197	147	1.23412	435	1.82044	870	2.70603
28	0.99186	88	1.11401	148	1.23616	440	1.83062	880	2.72638
29	0.99389	89	1.11604	149	1.23819	445	1.84080	890	2.74674
30	0.99593	90	1.11808	150	1.24023	450	1.85098	900	2.76710
31	0.99796	91	1.12011	155	1.25041	455	1.86116	910	2.78746
32	1.00000	92	1.12215	160	1.26059	460	1.87134	920	2.80782
33	1.00204	93	1.12419	165	1.27077	465	1.88151	930	2.82818
34	1.00407	94	1.12622	170	1.28094	470	1.89169	940	2.84853
35	1.00611	95	1.12826	175	1.29112	475	1.90187	950	2.86889
36	1.00814	96	1.13029	180	1.30130	480	1.91205	960	2.88925
37	1.01018	97	1.13233	185	1.31148	485	1.92223	970	2.90961
38	1.01221	98	1.13436	190	1.32166	490	1.93241	980	2.92997
39	1.01425	99	1.13640	195	1.33184	495	1.94259	990	2.95033
40	1.01629	100	1.13844	200	1.34202	500	1.95277	1,000	2.97068
41	1.01832	101	1.14047	205	1.35220	505	1.96295	1,025	3.02158
42	1.02036	102	1.14251	210	1.36238	510	1.97313	1,050	3.07248
43	1.02239	103	1.14454	215	1.37256	515	1.98331	1,075	3.12337
44	1.02443	104	1.14658	220	1.38274	520	1.99349	1,100	3.17427
45	1.02647	105	1.14862	225	1.39292	525	2.00366	1,125	3.22516
46	1.02850	106	1.15065	230	1.40309	530	2.01384	1,150	3.27606
47	1.03054	107	1.15269	235	1.41327	535	2.02402	1,175	3.32694
48	1.03257	108	1.15472	240	1.42345	540	2.03420	1,200	3.37785
49	1.03461	109	1.15676	245	1.43363	545	2.04438	1,225	3.42875
50	1.03664	110	1.15879	250	1.44381	550	2.05456	1,250	3.47964
51	1.03868	111	1.16083	255	1.45399	555	2.06474	1,275	3.53054
52	1.04072	112	1.16287	260	1.46417	560	2.07492	1,500	3.58143
53	1.04275	113	1.16490	265	1.47435	565	2.08510	1,325	3.63233
54	1.04479	114	1.16694	270	1.48453	570	2.09528	1,350	3.68323
55	1.04682	115	1.16897	275	1.49471	575	2.10546	1,375	3.73412
56	1.04886	116	1.17101	280	1.50489	580	2.11564	1,400	3.78502
57	1.05090	117	1.17305	285	1.51507	585	2.12581	1,425	3.83591
58	1.05293	118	1.17508	290	1.52524	590	2.13599	1,450	3.88681
59	1.05497	119	1.17712	295	1.53542	595	2.14617	1,475	3.93770
60	1.05700	120	1.17915	300	1.54560	600	2.15635	1,500	3.98860

Volume at given temperature = Volume at 32° × constant for given temperature.

gen in the air into intimate contact with the fuel ingredients.

The heat liberated per hour will be

952 × 14,500 = 13,804,000 B.t.u. by carbon,

51.1 × 51,804 = 2,647,184.4 B.t.u. by hydrogen.

Total = 16,451,184.4 B.t.u per hour.

This is on the assumption that all of the carbon is burned to CO_2.

EXAMPLE 2

A gas engine is to operate on producer gas containing, by volume, 9 per cent. of hydrogen, 5 per cent. of methane, 0.6 per cent. of ethylene, 24 per cent. of carbon monoxide, 5 per cent. of carbon dioxide, 0.4 per cent. of oxygen and 56 per cent. of nitrogen. Allowing an excess of air of 50 per cent. beyond the quantity theoretically required for combustion, how many cubic feet of air per cubic foot of gas will be needed and what will be the calorific value of the mixture per cubic foot at 70 degrees Fahrenheit?

ANSWER

0.09 cu.ft. of H = 0.000503 lb.
0.05 cu.ft. of CH_4 = 0.002229 lb.
0.006 cu.ft. of C_2H_4 = 0.000469 lb.
0.24 cu.ft. of CO = 0.018735 lb.
0.004 cu.ft. of O = 0.000357 lb.

The oxygen will combine with 0.000357 ÷ 8 = 0.0000446 pound of hydrogen to form water vapor, leaving 0.0004584 pound of hydrogen requiring air. At 32 degrees the quantity of air theoretically required will be

0.0004584 × 430.852 = 0.1975 cu.ft.,
0.002229 × 215.426 = 0.4802 cu.ft.,
0.000469 × 184.651 = 0.0866 cu.ft.,
0.018735 × 30.776 = 0.5766 cu.ft.

Total = 1.3409 cu.ft.

At 70 degrees temperature the quantity of air per cubic foot of gas will be the same as at 32 degrees, and with the 50 per cent. allowance this will be practically 2 cubic feet. One cubic foot of the mixture, therefore, will contain one-third of a cubic foot of gas, and the heat value of a cubic foot of gas is as follows

0.000503 × 51804 = 26.06 B.t.u.
0.002229 × 21592.8 = 48.13 B.t.u.,
0.000469 × 19834.2 = 9.30 B.t.u.,
0.018735 × 4305.6 = 82.35 B.t.u.

Total = 165.84 B.t.u.

per cubic foot of gas, or 55.28 B.t.u. per cubic foot of mixture at 32 degrees temperature. At 70 degrees, the heat value will be

55.28 ÷ 1.07736 = 51.3

B.t.u. per cubic foot of mixture.

In stating this example, the figures for the composition of the gas were taken at random; the resulting heat value is somewhat higher than is obtained in ordinary practice, but that does not affect the application of the tables to the problem.

Bursting Strength of Malleable-iron Pipe Fittings

BY S. M. CHANDLER

A number of tests were recently made by the writer at the laboratories of the Pittsburgh Valve and Fittings Company, to determine the bursting strength of 4-inch standard, screwed, malleable-iron tees, black and galvanized. Following are given the ultimate test pressures at which these fittings failed, together with the weights of fittings tested:

Test No.	Black or Galvanized.	Ultimate Test Pressure.	Weight, Pounds.
1	Black.	2800 lb.	10.06
2	Black.	3100 lb.	10.12
3	Black.	2800 lb.	10.19
4	Galvanized.	2700 lb.	10.62
5	Galvanized.	3000 lb.	10.50
6	Galvanized.	2800 lb.	10.75

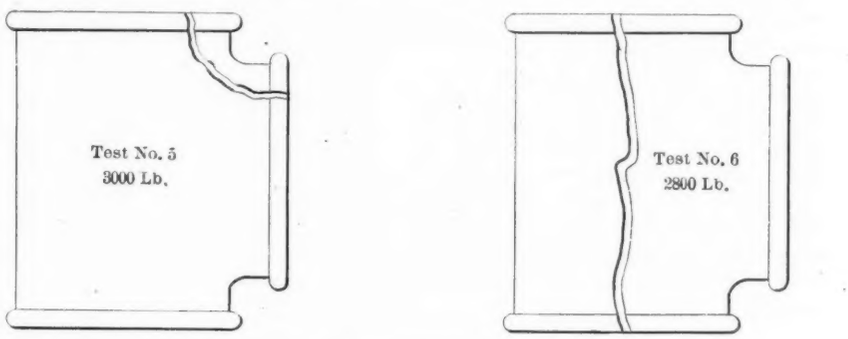
The bodies of all fittings were ¼ inch in thickness.

The average bursting pressure of the black fittings was 2900 pounds, and of the galvanized fittings 2833 pounds. As these tees were recommended for a working pressure of only 150 pounds, they therefore had a factor of safety of 19.3 for the black fittings and 18.9 for those galvanized, with a general average factor of safety of 19.1 for black and galvanized together. This is ample where the fittings are used at pressures recommended by the manufacturer and would even allow of safe usage at still higher pressures.

It is interesting to note that the galvanized fittings failed at practically the same pressures as the black. This is contrary to the expressed belief of many users of malleable fittings, who were very positive in their statements that galvanizing greatly weakened the strength of pipe fittings. Adherents to this theory claimed that dipping malleable fittings into a bath of molten zinc, and then suddenly cooling by immersing them in cold water, had a tendency to make the castings hard and brittle, bringing them back to the unannealed state. That such a theory is false is shown conclusively by the above tests, leading one to infer that the temperature to which castings are raised for galvanizing is not sufficiently high to injure them when suddenly cooled, providing of course that the castings have been properly annealed in the first place.

A comparison of the bursting strength of cast-iron and malleable-iron fittings as used commercially can be obtained by referring to a series of tests, made by the writer on cast-iron fittings, which were the subject of an article appearing in the October, 1905, number of POWER. Here it was shown that three 4-inch standard, screwed, cast-iron tees were tested to destruction, failing at an average bursting pressure of 1867 pounds. As the average bursting pressure of the six 4-inch malleable fittings referred to above was 2867 pounds, they were therefore about one and a half times as strong as those made from cast iron. While tests to support this statement were only made applying to 4-inch sizes, it is probable that the same ratio would be approximately correct for all standard sizes as the patterns for both the malleable-iron and the cast-iron fittings were made from one general design.

In most cases the malleable fittings developed leakage through minute "pin holes" at pressures ranging from 1000 to 2500 pounds. In no instance were these pin-holes visible below a pressure of 1000 pounds with the black, or 2000 pounds with the galvanized fittings, while two of the galvanized fittings sustained pressures of 2500 pounds before pin-holes developed. It was therefore evident that the galvanizing was very effective in closing the pin-holes, which are generally characteristic of malleable fittings when used at high pressures.



CHARACTERISTIC FRACTURES OF GALVANIZED MALLEABLE-IRON TEES

A feature of interest that developed in these tests was the stretching of the metal in the fittings as the pressure increased. Careful measurement of the body of the tees with calipers before and after the application of pressure showed that the diameter had increased from ⅛ to ¼ of an inch. This stretch caused excessive leakage in the threads of the fittings at the higher pressures and made considerable trouble and annoyance in conducting the tests. On this account it was found advisable to raise the pressure, in making the tests, as quickly as possible, as in so

doing the fittings were fractured before they had had time to stretch and leak to any great extent. This sudden application of pressure no doubt had a tendency to produce failure of the fittings at lower pressures than if the pressure had been applied gradually without shock. This difficulty could have been avoided by screwing the plugs farther into the tees when the pressure had reached a point slightly below that at which the fittings were expected to fail. Such a procedure would however be accompanied with danger, as any air entrained in the tee might cause a disastrous accident with probable loss of life in case of premature bursting of a fitting.

The accompanying sketch shows characteristic fractures of the fittings tested. Most of the tees failed as in Test No. 5, cracking through the beads at one end and the side outlet of the fitting. No pieces of metal were entirely separated from the tees when they failed, as was the case with the cast-iron fittings. The malleable-iron fitting, being tough and slightly elastic, was simply torn apart while the cast-iron fitting, being more brittle, broke in many cases into separate and distinct pieces. These tests show plainly the superiority of malleable over cast iron for use in the manufacture of pipe fittings of small size.

Boiler Rules

The Board of Boiler Rules appointed under a recent act of the Massachusetts legislature has adopted the following regulations:

Section 1—Maximum Pressure on Boilers

1. The maximum pressure allowed on any steam boiler constructed wholly of cast iron shall not be greater than twenty-five (25) pounds to the square inch.

2. The maximum pressure allowed on any steam boiler the tubes of which are secured to cast-iron headers shall not be greater than one hundred and sixty (160) pounds per square inch.

3. The maximum pressure allowed on any steam boiler constructed of iron or steel shells or drums shall be calculated from the inside diameter of the outside course, the percentage of strength of the longitudinal joint and the minimum thickness of the shell plates; the tensile strength of shell plates to be taken as fifty-five thousand pounds per square inch for steel and forty-five thousand pounds per square inch for iron, when the tensile strength is not known.

Shearing Strength of Rivets

4. The maximum shearing strength of rivets per square inch of cross-sectional area to be taken as follows:

Iron rivets in single shear.....38,000 lb.
Iron rivets in double shear.....70,000 lb.
Steel rivets in single shear.....42,000 lb.
Steel rivets in double shear.....78,000 lb.

Factors of Safety

5. The lowest factors of safety used for steam boilers the shells or drums of which are directly exposed to the products of combustion and the longitudinal joints of which are of lap-riveted construction, shall be as follows:

(a) Five (5) boilers not over ten years old.

(b) Five and five-tenths (5.5) for boilers over ten and not over fifteen years old.

(c) Five and seventy-five hundredths (5.75) for boilers over fifteen and not over twenty years old.

(d) Six (6) for boilers over twenty years old.

(e) Five (5) on steam boilers the longitudinal joints of which are of lap-riveted construction, and the shells or drums of which are not directly exposed to the products of combustion.

(f) Four and five-tenths (4.5) on steam boilers the longitudinal joints of which are of butt and strap construction.

Section 2

Section 2 sets forth the standard form of certificate of annual inspection.

Section 3—Fusible Plugs

1. Fusible plugs, as required by section 20 chapter 465, Acts of 1907, shall be filled with pure tin.

2. The least diameter of fusible metal shall not be less than one-half (½) inch, except for working pressures of over one hundred and seventy-five (175) pounds gage, or when it is necessary to place a fusible plug in a tube; in which cases the least diameter of fusible metal shall not be less than three-eighths (⅜) inch.

3. The location of fusible plugs shall be as follows:

(a) In Horizontal Return-tubular Boilers—In the back head, not less than two (2) inches above the upper row of tubes, and projecting through the sheet not less than one (1) inch.

(b) In Horizontal Flue Boilers—In the back head, on a line with the highest part of the boiler exposed to the products of combustion, and projecting through the sheet not less than one (1) inch.

(c) In Locomotive Type or Star Water-tube Boilers—In the highest part of the crown-sheet, and projecting through the sheet not less than one (1) inch.

(d) In Vertical Fire-tube Boilers—In an outside tube, placed not less than one-third (1/3) the length of the tube above the lower tube-sheet.

(e) In Vertical Submerged-tube Boilers—In the upper tube-sheet.

(f) In Water-tube Boilers, Horizontal Drums, Babcock & Wilcox Type—In the upper drum, not less than six (6) inches above the bottom of the drum, and over the first pass of the products of combustion, projecting through the sheet not less than one (1) inch.

(g) In Stirling Boilers, Standard Type—In the front side of the middle drum, not less than six (6) inches above the bottom of the drum, and projecting through the sheet not less than one (1) inch.

(h) In Stirling Boilers, Superheated Type—In the front drum, not less than six (6) inches above the bottom of the drum, and exposed to the products of combustion, projecting through the sheet not less than one (1) inch.

(i) In Water-tube Boilers, Heine Type—In the front course of the drum, not less than six (6) inches from the bottom of the drum, and projecting through the sheet not less than one (1) inch.

(j) In Robb-Mumford Boilers, Standard Type—In the bottom of the steam and water drum, twenty-four (24) inches from the center of the rear neck, and projecting through the sheet not less than one (1) inch.

(k) In Water-tube Boilers, Almy Type—In a tube directly exposed to the products of combustion.

(l) In Vertical Boilers, Climax or Hazelton Type—In a tube or center drum not less than one-half (½) the hight of the shell, measuring from the lowest circumferential seam.

(m) In Cahall Vertical Water-tube Boilers—In the inner sheet of the top drum, not less than six (6) inches above the upper tube-sheet.

(n) In Scotch Marine Type Boilers—In combustion-chamber top, and projecting through the sheet not less than one (1) inch.

(o) In Dry-back Scotch Type Boilers—In rear head, not less than two (2) inches above the top row of tubes, and projecting through the sheet not less than one (1) inch.

(p) In Economic Type Boilers—In the rear head, above the upper row of tubes.

(q) In Cast-iron Sectional Heating Boilers—In a section over and in direct contact with the products of combustion in the primary combustion chamber.

(r) For other types and new designs, fusible plugs shall be placed at the lowest permissible water level, in the direct path of the products of combustion, as near the primary combustion chamber as possible.

On September 21 a 14,000-pound flywheel went to pieces at the Georgetown (Texas) Oil Mills and caused a damage of $4000.

Water-power Possibilities in South America

Numerous Waterfalls Make the Country Ideal for Projects for Electrical Generation, of which Several Are Now under Way

BY LEWIS R. FREEMAN

During a recent tour in South America the writer chanced to arrive in the interesting and progressive city of Santiago at the hight of the worst coal famine Chile had ever known. A heavily increased consumption, due to industrial expansion in all directions and some very questionable tactics on the part of the government railway management in endeavoring to secure control of the local output, had conspired to bring about a big shortage in the country's coal supply at a time when the fierce "northers" that sweep the Chilean coast during the winter made it practically impossible for sailing vessels to venture there. Before a fleet of especially chartered steam colliers brought tardy and costly relief, all the good coal in the country had been completely exhausted, and the wretched pickings from the dumps of the Lota and Coronel mines were selling at the equivalent of eight, and even ten, dollars in United States gold per ton.

In Valparaiso and Santiago electric cars ran on only three or four of the principal routes, and these were stopped early each afternoon in order to save coal to run the dynamos that furnished electricity for the few widely scattered street lights that were still kept burning. In the smaller cities of from twenty to a hundred thousand inhabitants, such as Talca, Chillan and Concepcion, conditions were even worse, passengers being conveyed only in cabs, while at night all the streets were in absolute darkness.

It was in the midst of this period of Egyptian night that the German company holding the lighting and street-transportation concessions in Valparaiso completed and put in operation a modern installation of turbines, driven by water from a fall near Pañuelos, ten miles distant from the city. Something between five and six thousand horse-power became instantly available, as a result of which the streets and parks of the city blazed forth once more with light, and the trolley service was re-established with more cars and faster schedules than ever before. The rest of the country, wrapped in darkness for another two months, had ample time to contemplate at leisure the example set for it, and to get the lesson to be learned therefrom well in mind for future reference.

For many weeks the most quoted remark to be heard on the west coast was the closing sentence of a statement made in a newspaper interview by an American engineer who chanced to be in Santiago at the time. After pointing out that western South America had more favorable opportunity for the generation of electricity from water power than any other portion of the globe, he concluded by saying:

"Under the circumstances, therefore, Chile, with all the fuss she has made over her losses and sufferings as a result of the coal famine, has about as much claim to sympathy as a man who stands up to his neck in a pool of clear water and cries for a drink because he is thirsty."

In the generation of electricity from water power, the two great essentials are fall and continuity of supply. Given sufficient of both at a place within practicable transmitting distance of the points where the electricity is to be used, power from water may ordinarily be produced cheaply enough to enter into successful competition with that generated in a steam plant, even in such sections as New York State, in the East, and Washington and California, in the West, where steam-fuels of all descriptions may be bought at minimum prices.

If conditions favorable to the generation of electricity from water power exist in a settled country where neither coal nor oil is found, and the price of electricity for lighting and traction purposes is high as a consequence, installations of that character, even after giving the country the benefit of lower-priced power, will yield the handsomest of profits. It is to the opportunities of this description offered at countless points on both slopes of the South American Andes that it is desired to call attention in this article.

Coal Production a Negligible Quantity

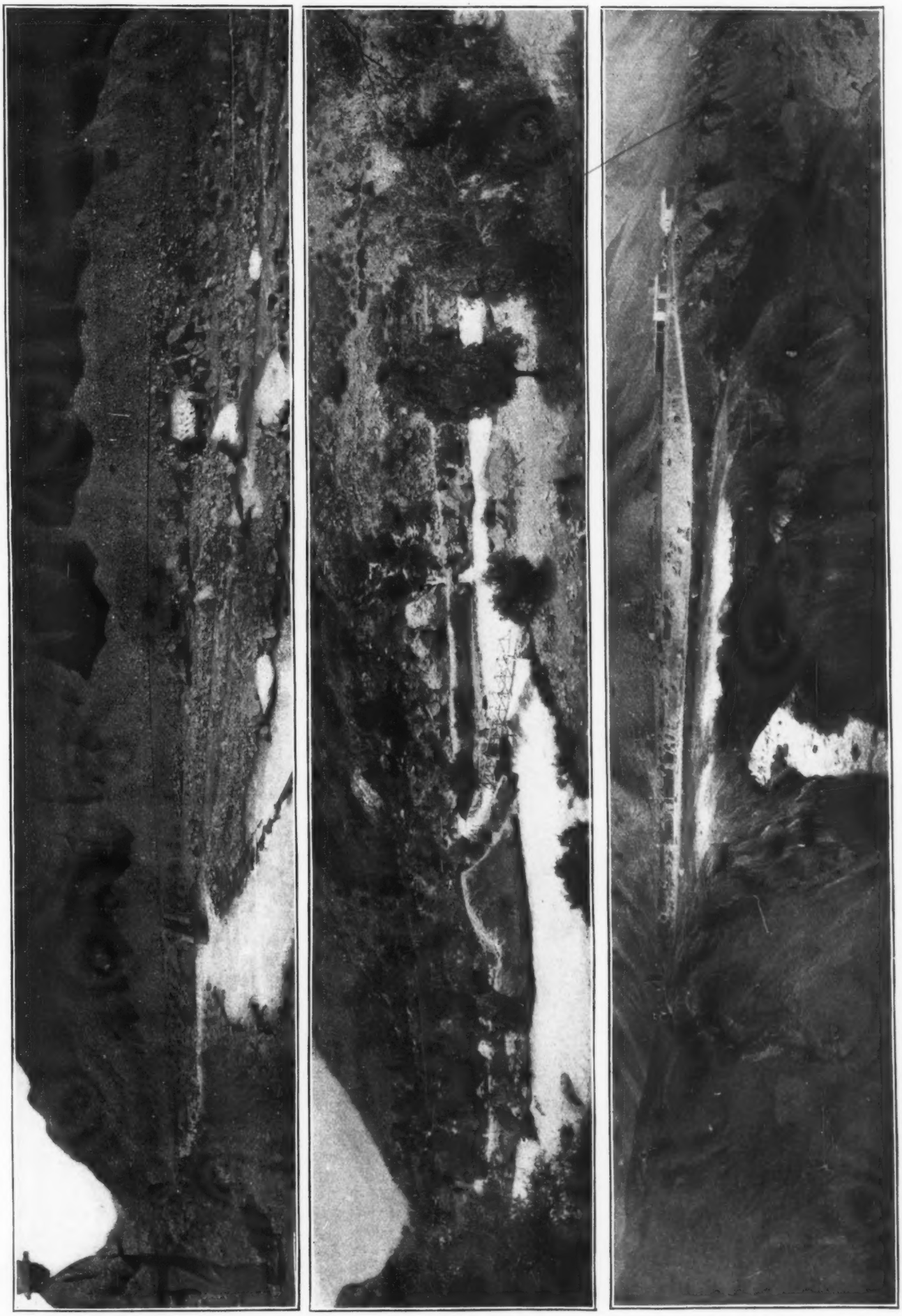
The coal production of South America may, for all practical purposes, be considered as an almost negligible quantity. The only mines on the whole continent that are being worked are those in the vicinity of Coronel and Lota in southern Chile, mines which turn out so poor an average product that they are generally referred to as stone-quarries. Almost all the coal consumed in South America, therefore, is imported, the bulk of it coming from Cardiff and Newcastle. This coal can be landed at the Brazilian and Rio Plate ports at a fairly reasonable figure, but when it is required for the west coast, the almost prohibitive insurance incident to the passage of Cape Horn and the exposure to the deadly "northers" in the unprotected ports of Chile makes it an extremely high-priced article.

The expensiveness of steam-fuel has been the greatest single industrial handicap that the Pacific coast of South America has had to contend with, yet had the people of that region only awakened to the fact, the best substitute in the world for steam in the capacity of a power generator has been running past their doors ever since there were any doors for the Andean rivers to run past.

It was no thoughtless statement—and, the writer is convinced by considerable observation in various quarters of the world, no exaggerated one—that the natural conditions in Chile for the development of electrical power were more favorable than elsewhere. There are in the eastern half of the continent two waterfalls, both of which are higher and of greater volume than any on the Pacific side of the divide, and located, as each of them is, in a remote and totally unsettled district, their practical usefulness for many years, at least, is largely problematical. In Chile, on the other hand, from the thirtieth parallel (north of which for several hundred miles are only the rainless deserts of the nitrate provinces) south to Cape Horn, there is not a city, town or hamlet that cannot be cheaply and efficiently served with electricity generated in most instances not over ten, and in no case over fifty, miles from its center. In Peru and Ecuador, while the distribution of settlement and the natural advantages are not so favorable as in Chile, the latter are far greater than in many places where water power has displaced steam in generating electricity, and, considering the increasing demand for power in those countries in the face of the high price of coal, it seems inevitable that there must shortly be great development along the same lines now being followed by their progressive southern neighbor.

A Spectacular Development Project

The most spectacular single power-development project in Chile is that in connection with the great falls of the Rio Laja in the south-central section. The Laja is the main branch of the Biobio, the largest of the southwest coast rivers, and its volume may be roughly estimated at about half that of the Hudson. The falls, which average more than a hundred feet in hight, are unfortunately not located



WATER POWERS RUNNING TO WASTE IN SOUTH AMERICAN RIVERS

within economical transmitting distance of the principal population-center of the country, the district lying between Santiago and Valparaiso and including the large cities and towns of the Aconcagua valley.

Concepcion and its port, Talcahuano, with a combined population in excess of a hundred thousand, and Chillan, with a population of thirty thousand, are the only important places that will benefit materially by the carrying out of the now well-advanced plans for harnessing the Laja, but the building of numerous industrial establishments at favorable locations on the government railway within a short distance of the falls is definitely assured. It is also planned to operate several divisions of the railway, and their branches, with power from the same source.

If the rich and beautiful Santiago-Valparaiso district will not benefit from the Laja proposition, it may still draw power from half a dozen different sources, any one of which could alone supply its rapidly growing demand for many years to come. The most favorable, and likewise the most advanced, project at this point is that of installing a series of water-driven turbines on the upper portions of the Rio Aconcagua, and its principal branch, the Colorado. The former, as its name would indicate, takes its rise and draws most of its flow from the Pacific watershed of the great 23,500-foot peak of Aconcagua, the highest mountain in the Western Hemisphere. This famous mountain—in common with others of a chain of peaks so lofty that the average altitude of the continental divide for a distance of several hundred miles in either direction is in the vicinity of 18,000 feet above sea level—except in the most exposed places, carries a perpetual snow-cap which, even at the end of summer, extends for many thousand feet down from from its cloud-piercing summit. Fed from such exhaustless founts, the rivers that rise in the higher Andes, irrespective of what the seasons may be in the valleys, flow strongly and constantly throughout the year. Their flow of snow-water is greatest in the hot summer months, but when the winter's cold begins to restrict the supply from this source, the rains of that season come on and keep up the flow. until the spring thaw commences.

SOUTH AMERICAN WATERFALLS THAT VIE WITH NIAGARA

In installing one of these water-power plants the expense involved may be generally reckoned to be in inverse ratio to the natural fall of the river from which water is taken, the minimum expenditure being where the drop is perpendicular, as at a waterfall. There are few falls of great hight on the Aconcagua or Colorado, but above their junction a few miles east of the city of Los Andes, each is so continuous a succession of rapids and cascades that, from bank to bank for miles, their water is as white as the snow from which it comes. The two streams are of about the same volume, but the Colorado has rather the more precipitous course of the two. In twenty-five miles it falls away more than 12,000 feet, while the drop of the Aconcagua is about 8000 feet in the same distance. There are few points where a fall of several hundred feet cannot be obtained inside of a mile, and the minimum flow of either is sufficient, if utilized at half of the available points, to amply supply the needs of the adjacent territory for the next fifty years.

Machinery from the United States

The companies which hold the concessions for the water power of these streams are Chilean, but their consulting engineers are American, and their machinery will also come from the United States. The first plant built will be in sight of the new transcontinental railway, now almost completed between Valparaiso and Buenos Aires, and it is probable that one of the first uses to which the power is put will be in operating the Chilean Trans-Andine section of this road. Another improvement—long projected, but never carried out on account of the cost of power—that will spring into being with the completion of these plants is the electric road between Valparaiso and Santiago. This will involve a hundred miles of costly construction, but, with cheap power, the heavy expenditure necessary will be fully warranted by the great movement of freight and passengers between the Chilean capital and its principal port. The impulse of cheap electricity for manufacturing plants will be the biggest lift Chilean industry has ever received, and all in all there are not fewer than a million people who will benefit, directly or indirectly, through the development being pushed on the Aconcagua and Colorado.

As stated, there are several perfectly feasible projects for developing power for Santiago and Valparaiso at other points than on the Aconcagua, but as the scheme regarding the latter is already being carried out it would not seem that there would be any reason for doing anything with the other propositions for a good many years.

South from Santiago for several hundred miles—between a low coast-range and the main "backbone" of the Andes—stretches an open series of connected valleys, which, closely settled and intensely cultivated, forms what is generally conceded to be the "garden spot" of South America. Towns of from five to thirty thousand people follow each other in steady succession along a railway line that is already in process of being double-tracked to meet the increase of business. Back of these towns tower the 20,000-foot summits of the mountains, while through, or near, each of them flows one or more rivers from its source in the exhaustless Andean snows. Not a town of them but has an Aconcagua of its own, and hardly one of them but is doing all it knows how to pave the way for a big power plant of its own. Undoubtedly some of these will be built, notably in such places as the present manufacturing center of Talca, which has 40,000 people and numerous factories of all kinds.

Where the Possibilities are Unlimited

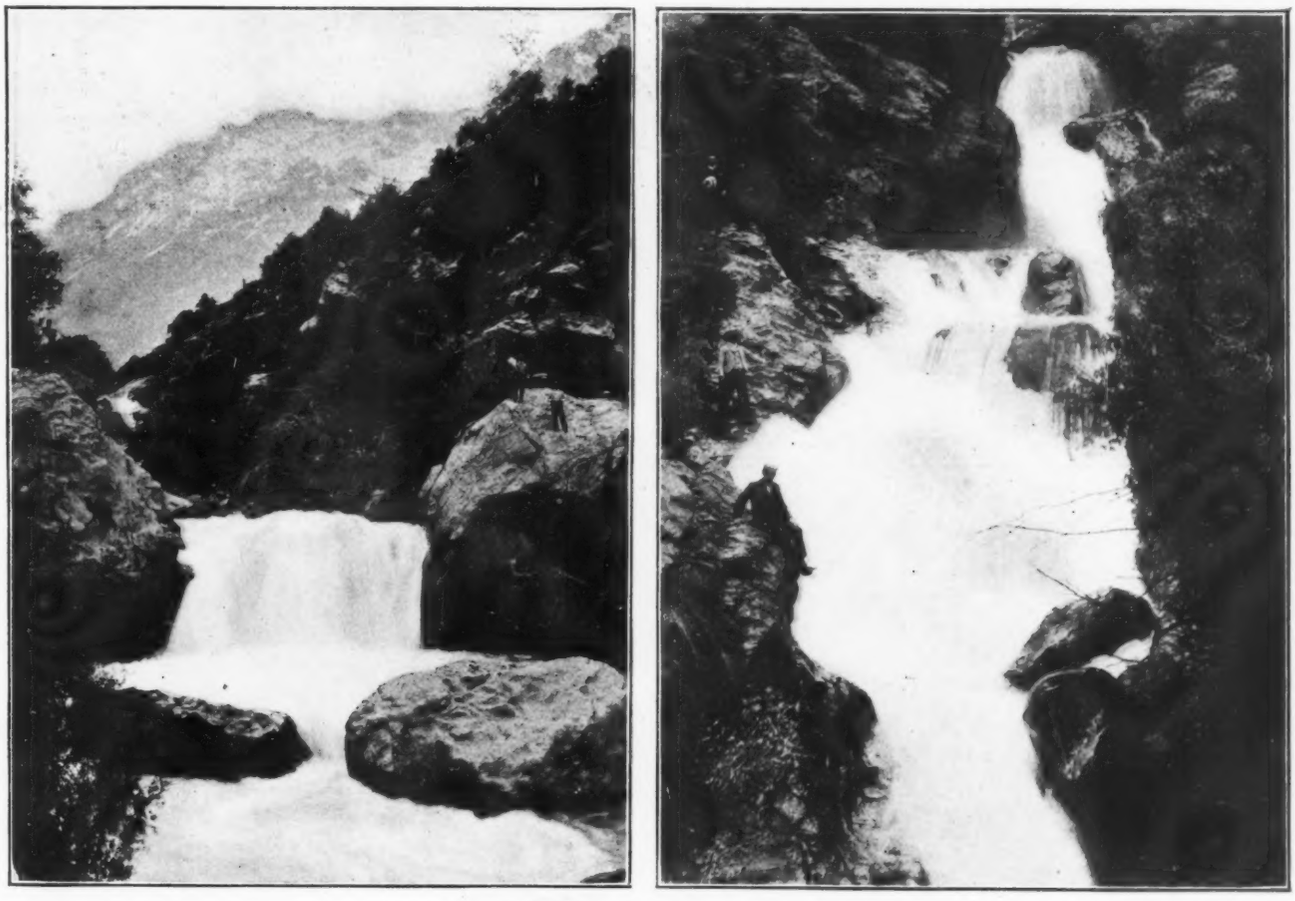
In the south of Chile, where the heavy all-the-year-round rainfall is responsible for rivers of much greater volume than in the north, the possibilities for power development are unlimited; unfortunately, however, on account of the present sparseness of settlement, there would be scant use for electricity at any price. Nevertheless, one notable proposition, that of the fall of the Perihueico, is already under exploitation.

This fall occurs between the lakes of Perihueico and Panguipulli, alongside the pass of San Martin, by which a railroad is now building to connect Chile and Argentina, and, ultimately, the Atlantic and Pacific. These lakes, though but ten miles apart, have a difference in elevation of 1200 feet, a sixth of which is negotiated by the connecting river at a single bound. The Chilean company building the railroad through the pass will use the power generated at this point to operate its trains, run an extensive system of sawmills and, if practicable, in working a lock that is being constructed as an aid to navigation between two of the remoter lakes.

On the eastern slopes of the Andes conditions for power development are scarcely less favorable than on the western, but, as in southern Chile, there are few places where the settlement is dense enough to warrant the requisite investment of capital. A striking exception occurs in the Argentine province of Mendoza, where the river of that name comes roaring down the Atlantic divide from the summit of the Uspallata pass in fashion similar to that of the Aconcagua on the Pacific side. Most of the Mendoza's water, in fact, comes from the great peak of Aconcagua, and the supply is no less inexhaustible than on the western slope.

The province of Mendoza is rich and populous and, though rainless, has become through irrigation and the scientific cultivation of its rich soil the greatest vine-growing and wine-making district south of the equator. Last year its output of wine alone was valued at forty million dollars, and a steady increase is expected for many years. The worst drawback the section has had is that of the expensiveness of power for the wineries, due to the high price of coal, a difficulty of which little should be heard after May of next year, the date at which the concessionaries for the water-power rights of the Rio Mendoza must have their first plant in operation.

In conclusion, a word in regard to the two great falls of South America, the Yguazu and the Kaiteur. The former of these is located on the Upper Parana river between Paraguay and Argentina,



TWO CHILEAN FALLS AMONG THE SNOW-CAPPED ANDES

and the latter on the Potaro, a large branch of the Essequibo, in British Guiana; on the score of grandeur and impressiveness either is worthy of being ranked with Niagara and Victoria at the head of the list of the great cataracts of the world. Yguazu will average higher than Niagara, and at times probably flows nearly an equal amount of water. In form it is more broken and generally less regular than the great American fall, but makes up for what it loses in this respect in the wild riot of tropical vegetation that surrounds it. A concession of its power rights on the Argentine side was granted to an English company a little more than a year ago, but nothing of importance has yet been done. To be of value its power must be transmitted to Montevideo, Buenos Aires, and Rosario, and, as each of these cities is approximately five hundred miles from the fall itself, it would appear that the time is not quite yet ripe for active operations.

Kaiteur, three hundred feet wide, seven hundred feet in hight, and situated within six degrees of the equator, is one of the grandest and, at the same time, one of the least known of all the great sights of the world. As reaching it involves the fitting out of an expensive expedition and a continuous up-river trip of three hundred miles, with numerous portages at rapids, one is not surprised to learn that less than fifty white men are said to have looked upon it. Though in a straight line this splendid cataract is probably within direct transmitting distance of Georgetown and the big sugar mills along the coast, the general backwardness of the country would lead one to the conclusion that its enormous forces are destined to run to waste for a good many years to come.

The Scranton Explosion

After our October number went to press, we obtained further particulars of the explosion of the horizontal return-tubular boiler, at Scranton, Penn., referred to on page 726 of last month's paper. As

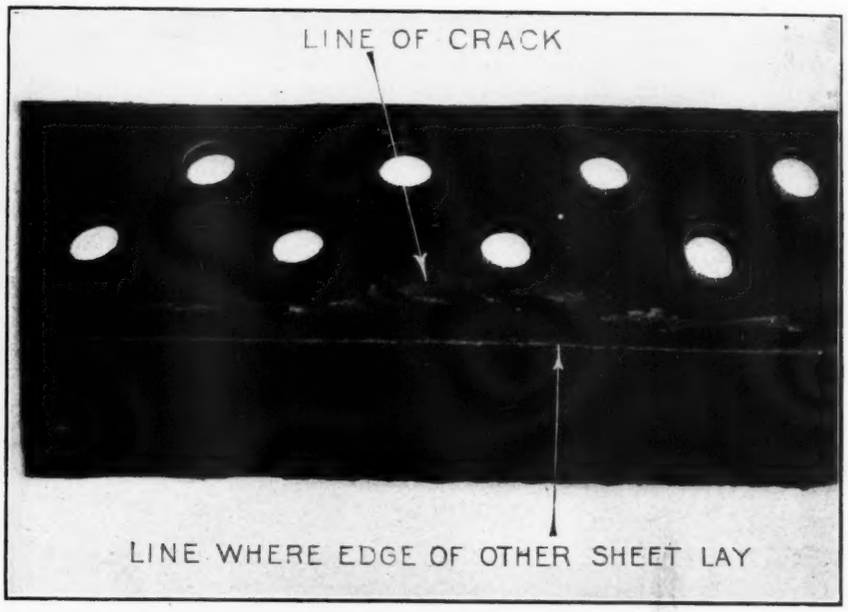


FIG. 2. SHOWING CRACK IN THE LAP-JOINT

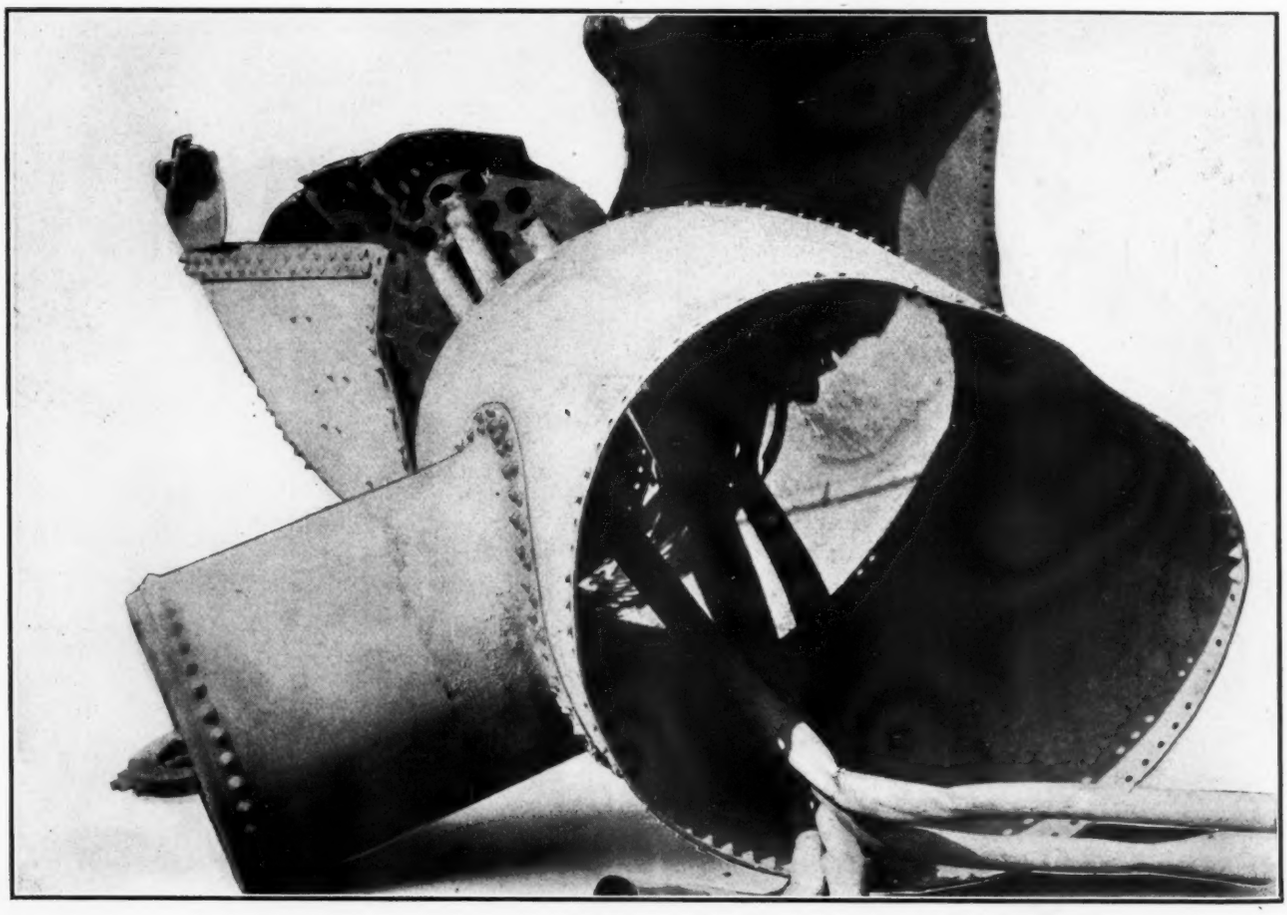


FIG. 1. EXPLODED BOILER AT THE ROBBINS AND SPENCER MILL, SCRANTON, PENN.

will be seen by Fig. 1 herewith, the middle ring of the boiler did not fail; therefore, its longitudinal joint was cut apart to determine the condition of the metal. The sheet was found to be seriously cracked on the internal surfaces of the lap-joint, as shown in Fig. 2, leaving no doubt that the explosion was another example of those due to the lap-riveted joint. Fig. 3 shows a portion of sheet from one of the exploded rings and exposes how badly the metal was crumpled. Fig. 4 is a reproduction of some of the coupons cut from the exploded sheet, further showing that they were not lacking in ductility. Results of tests upon these coupons were as follows:

No. 1 coupon, taken from the front ring girthwise near the lug, beginning at the fracture—Area, 0.5206 square inch; load, 31,400 pounds; tensile strength, 60,315 pounds; reduced area, 0.239 square inch, a reduction of 54.1 per cent.; elongation, 1.531 or 19.1 per cent.

No. 2 coupon, taken longitudinally from the front ring at right angles to No. 1 coupon, near the fracture—Area, 0.5490 square inch; load, 32,600 pounds; tensile strength, 59,380 pounds; reduced area, 0.2422 square inch, a reduction of 55.9 per cent.; elongation, 1.125 or 14 per cent.

No. 3 coupon, taken girthwise from the middle ring beginning at the long seam, near the girth seam—Area, 0.5359 square inch; load, 32,800 pounds; tensile strength, 61,205 pounds; reduced area, 0.25887 square inch, a reduction of 51.7 per cent.; elongation, 1.625 or 20.3 per cent.

Under the auspices of the Association of Employees of the New York Edison Company, a series of lectures on electrical engineering was inaugurated October 1, to continue through the winter.

Tests of Internal-combustion Engines with Alcohol

The Department of Agriculture has just issued a report of a valuable series of tests of oil engines made by Prof. Charles E. Lucke and S. M. Woodward. Eight engines were tested with the fuel for which they were designed and also with alcohol, all except one being gasolene engines; the exception was a Mietz & Weiss kerosene engine. It is impracticable to present here the results of the tests in full; the general conclusions deduced from the tests were as follows:

(1) Any gasolene engine of the ordinary types can be run on alcohol fuel without any material change in the construction of the engine. The only difficulties likely to be encountered are in starting and in supplying a sufficient quantity of fuel; the quantity must be considerably greater than the quantity of gasolene required.

(2) When an engine is run on alcohol its operation is quieter than when run on gasolene, its maximum power is usually materially higher than it is on gasolene, and there is no danger of injurious hammering with alcohol, such as may occur with gasolene.

(3) For automobile air-cooled engines alcohol seems to be especially well adapted as a fuel, since the temperature of the engine cylinder may rise much higher before automatic ignition takes place than is possible with gasolene; and if automatic ignition of the alcohol fuel does occur no injurious hammering results.

(4) The consumption of fuel in pounds per hour per brake horse-power, whether the fuel is gasolene or alcohol, depends chiefly upon the horse-power at which the engine is being run and upon the setting of the fuel supply valve. It is easily possible for the fuel consumption per horse-power-hour to be increased to double the best value, either by running the engine on a load below its full power or by a poor setting of the fuel supply valve.

(5) The fuel consumption is affected by the time of ignition, by the speed, and by the initial compression of the fuel charge. No tests were made to determine the maximum possible change in fuel consumption that could be produced by changing the time of ignition, but when near the best fuel consumption it was shown to be important to have an early ignition. So far as tested, the alcohol fuel consumption was better at low than at high speeds; and increasing the compression from 70 to 125 pounds produced only a very slight improvement in the consumption of alcohol.

(6) It is probable that for any given engine the fuel consumption is also affected by the quantity and temperature of cooling water used and the nature of the cooling system, by the type of ignition apparatus, by the quantity and quality of lubricating oil, by the temperature and humidity of the atmosphere, and by the initial temperature of the fuel.

(7) It seems probable that all well-constructed engines of the same size will have approximately the same fuel consumption when working under the most advantageous conditions.

(8) With any good small stationary engine as small a fuel consumption as 0.70 pound of gasolene, or 1.16 pounds of alcohol per brake horse-power-hour may reasonably be expected under favorable conditions. These values correspond to 0.118 and 0.170 gallon, respectively, or 0.95 pint of gasolene and 1.36 pints of alcohol. Based on the "high" calorific values of 21,120 British thermal units per

FIG. 3. SHOWING HOW SHEET CRUMPLED

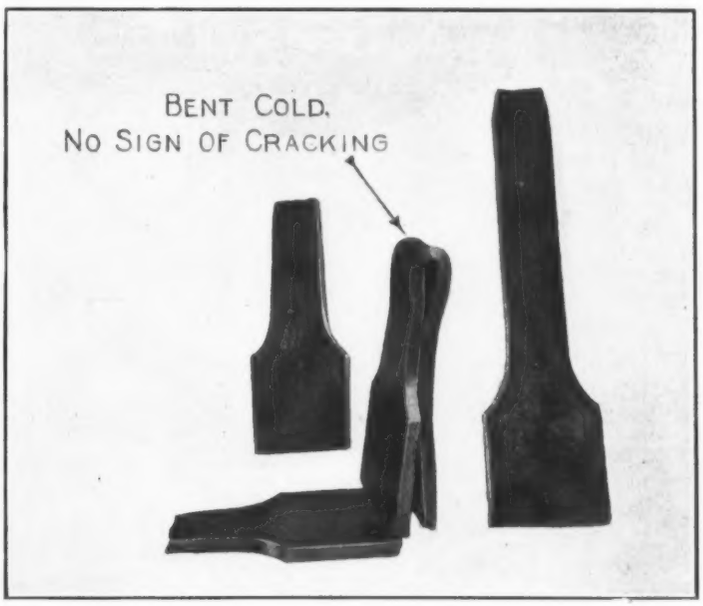


FIG. 4. COUPONS FROM EXPLODED SHEET

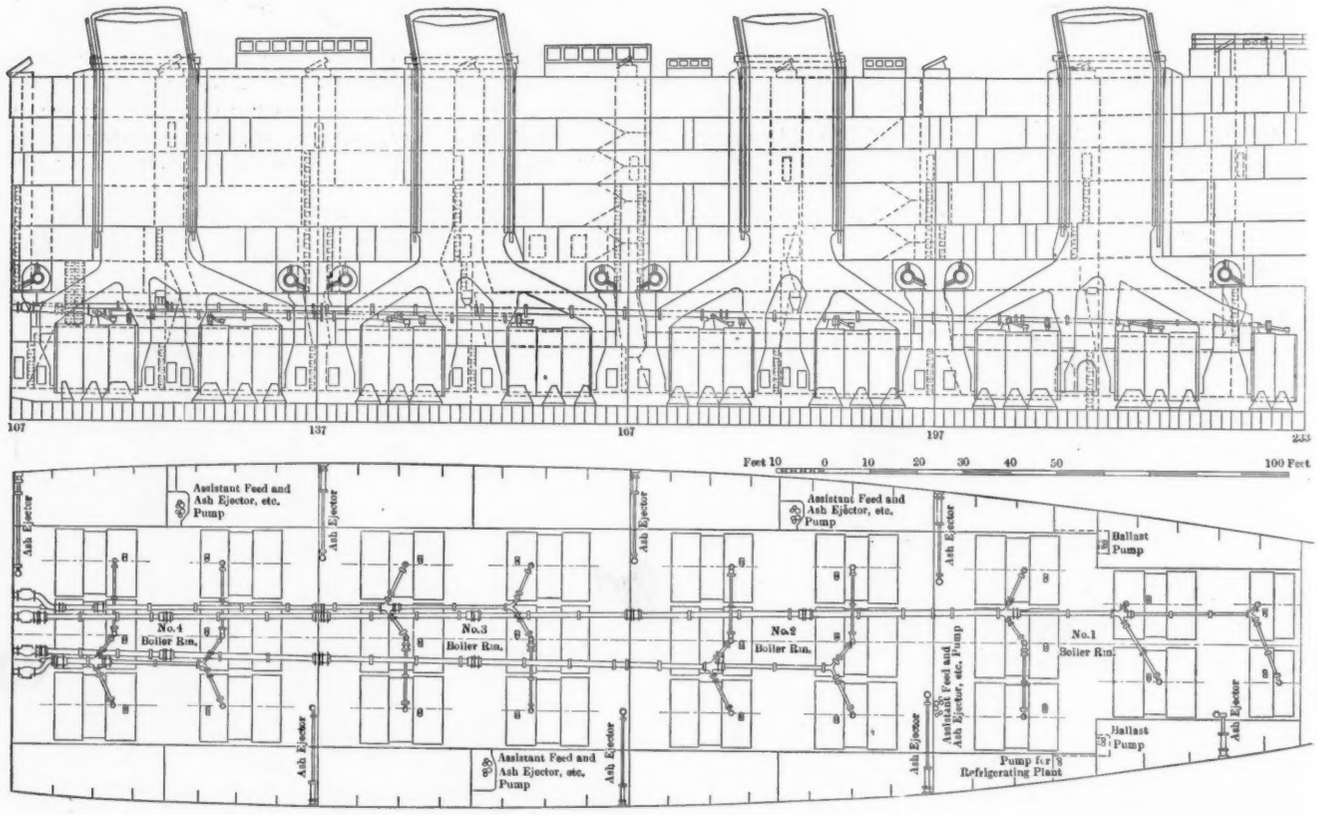
pound of gasolene and 11,880 per pound of alcohol, these consumptions represent thermal efficiencies of 17.2 per cent. for gasolene and 18.5 per cent. for alcohol. But calculated on the basis of the "low" calorific values of 19,660 British thermal units per pound for gasolene and 10,620 for alcohol, the thermal efficiencies become 18.5 for the former fuel and 20.7 for alcohol. The ratio of the high calorific values used above is, gasolene to alcohol, 1.78. The corresponding ratio of the low calorific values is 1.85. The ratio of the consumptions mentioned above is, alcohol to gasolene, 1.66 by weight, or 1.44 by volume.

The report of the tests is contained in Bulletin No. 191 of the Office of Experiment Stations, United States Department of Agriculture, Washington, D. C. A copy may be obtained without cost by application to A. C. True, director of experiment stations.

A paper entitled, "On the Art of Cutting Metals," by Frederick W. Taylor, which was the presidential address at the last annual meeting of the American Society of Mechanical Engineers, has been reprinted and bound in cloth by the society, to sell for $3. This or any other publication of the society may be had by addressing the secretary, 29 West Thirty-ninth street, New York. It is not necessary to send orders through members. None of the publications of the society is copyrighted.

The Power Plant of the "Lusitania"

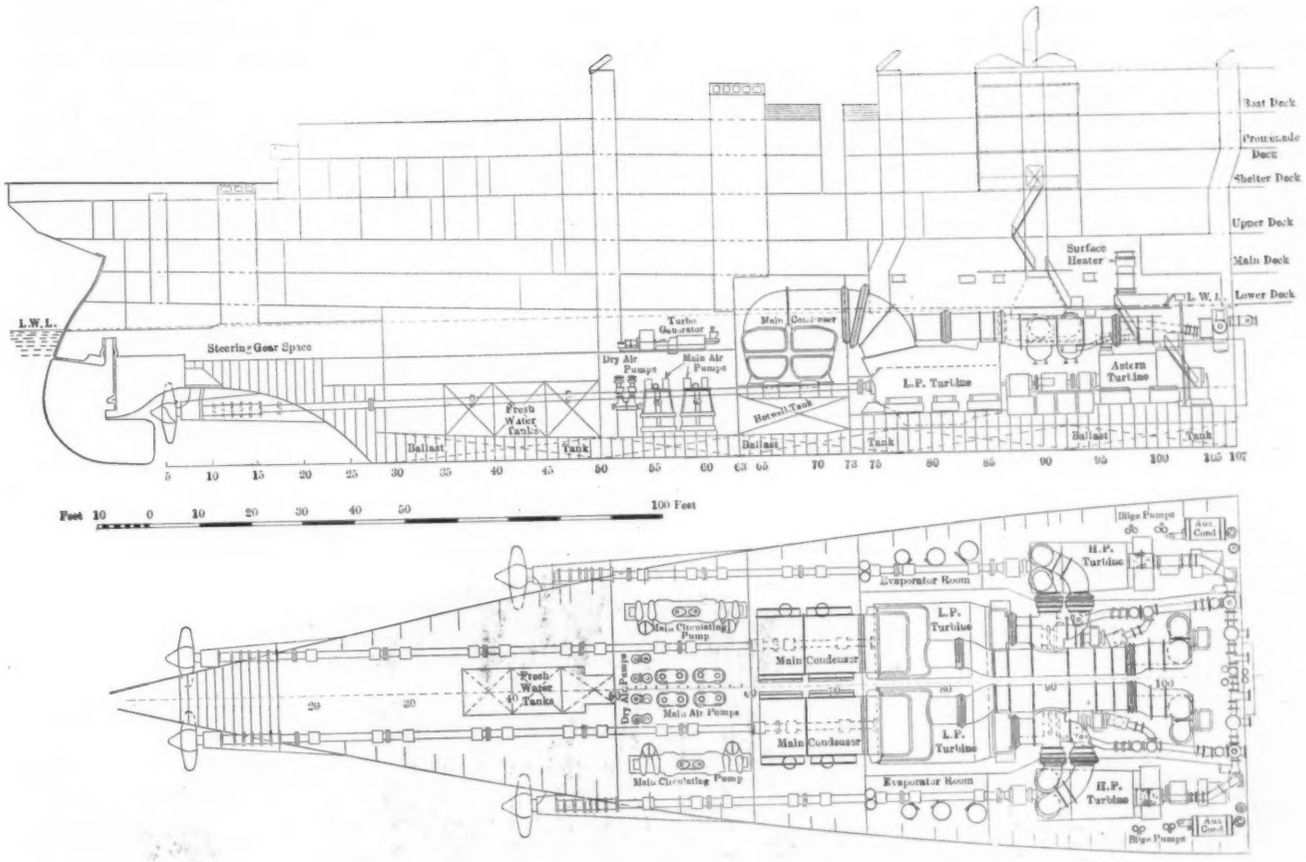
The new Cunard liner "Lusitania" which at this writing had just successfully completed her first round trip, is the most powerfully engined vessel afloat, having some 70,000 horse-power and a guaranteed speed of 24½ knots in all weathers. Our English contemporary, *Engineering*, publishes a detailed description of the vessel, from which the accompanying illustrations are reproduced. The main propelling machinery consists of two high-pressure ahead, two low-pressure ahead, and two astern turbines of the Parsons type. Owing to the immense size of these turbines, and in order to comply with the admiralty's requirements as to subdivision, the main propelling and auxiliary machinery are located in nine different water-tight compartments. In the largest and most central of these are located the two low-pressure and two astern turbines, all of the feed-pumps the hot-well pumps, oil pumps, and the pumps for the hydraulic system of closing bulkhead doors. In each of the two wing compartments, separated from the central compartment by a longitudinal bulkhead, is a high-pressure turbine, with auxiliary condensers, auxiliary circulating and air pumps, also the water-service, fire, and bilge and fresh-water pumps. Aft of these, in separate wing compartments, are placed the evaporating and distilling plants, underneath which runs a portion of the high-pressure tunnel shafting. In the fifth compartment, extending right across the ship, are placed the four main condensers, and underneath these the feed-tank. Aft of these again are the two auxiliary machinery rooms, each two stories and each self-contained. In the lower are placed the main wet-air pumps, dry-air pumps and main centrifugal circulating pumps, and on each of the upper platforms the electric generating station, in which the power is supplied by two Parsons turbo-generators. Abaft of these are the shaft tunnels. The starting gear is situated on an upper platform at the forward end of the main engine rooms, and from this position practically everything can be controlled.



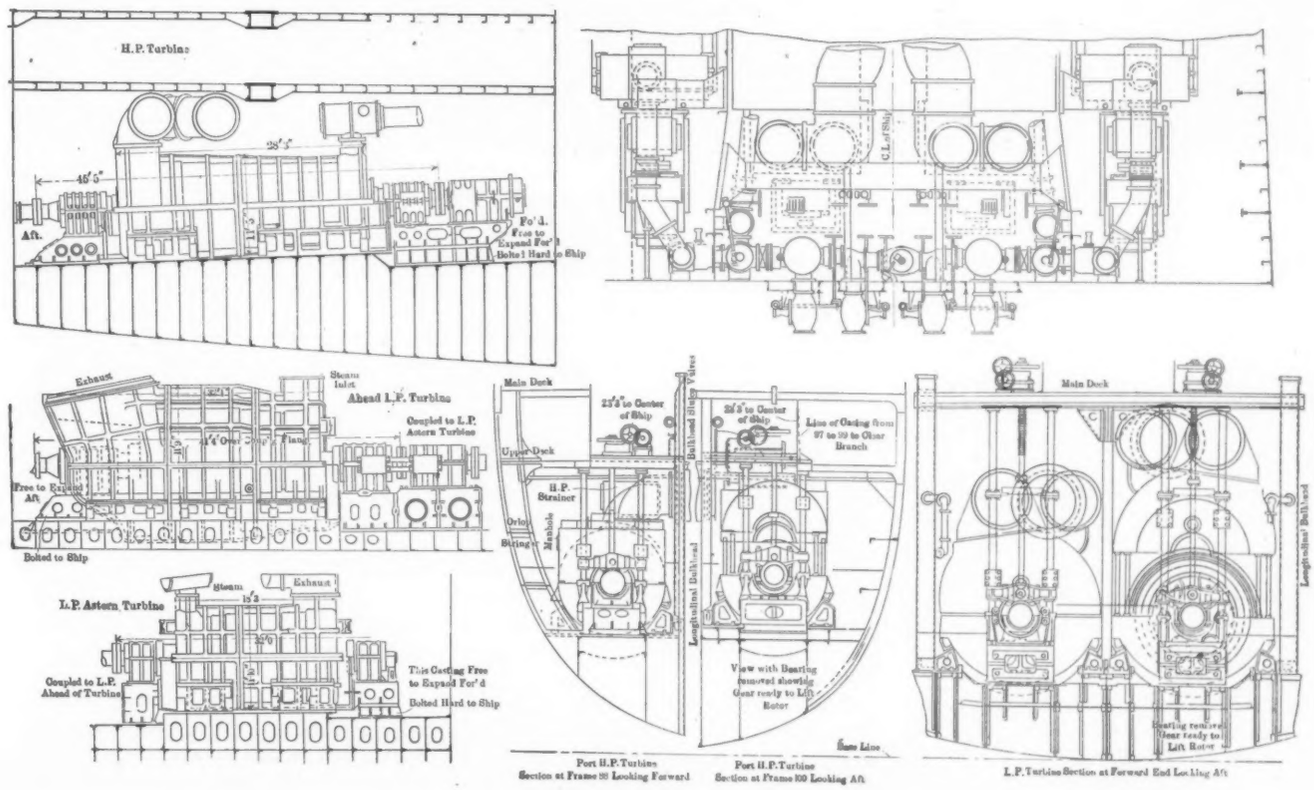
GENERAL ARRANGEMENT OF THE BOILERS OF THE "LUSITANIA"

There are 23 double-ended and two single-ended boilers in the ship, situated in four separate water-tight compartments. The forward boiler room has two single-ended and four double-ended boilers, and in each of the other rooms there are located six double-ended boilers in groups of three athwart the ship. The double-ended boilers are 17½ feet in diameter by 22 feet long, and in each of these boilers there are 344 stay-tubes and 720 plain tubes, the total being 1064. The total heating surface is 6539 square feet and the grate area 168.65 square feet. There are separate combustion chambers to each furnace, and the water and steam spaces are ample.

The furnaces have a collective grate



GENERAL ARRANGEMENT OF THE TURBINES OF THE "LUSITANIA"



DETAILS OF THE TURBINES OF THE "LUSITANIA"

area of 4048 square feet, while the total heating surface is 158,350 square feet. For each group of boilers there is a separate funnel, all being of the same dimensions, as the heating room and boiler room are identical. These funnels are elliptical in form, the extreme dimensions of the outer funnel being 19x26 feet, while the hight above the grate level is 130 feet. The shells of the boilers are made of high-tensile steel, of a maximum tensile strength of 36 tons to the square inch; but the fronts and backs, as also all rivets, including those for the shells, are made of ordinary mild steel. The 192 furnaces are of the cambered type, which is a specialty of the Atlas Works, Sheffield, belonging to John Brown & Co., builders of the vessel. These furnaces were made to a diameter over ribs into short lengths connected by brass tubes in which they could slide. Sirocco fans are used for supplying forced draft. The engineering staff comprises 33 engineers, 192 firemen, 120 trimmers, 21 greasers and 3 refrigerating engineers. The rotor illustrated is for one of the low-pressure turbines and weighs 11¾ tons.

Coalite

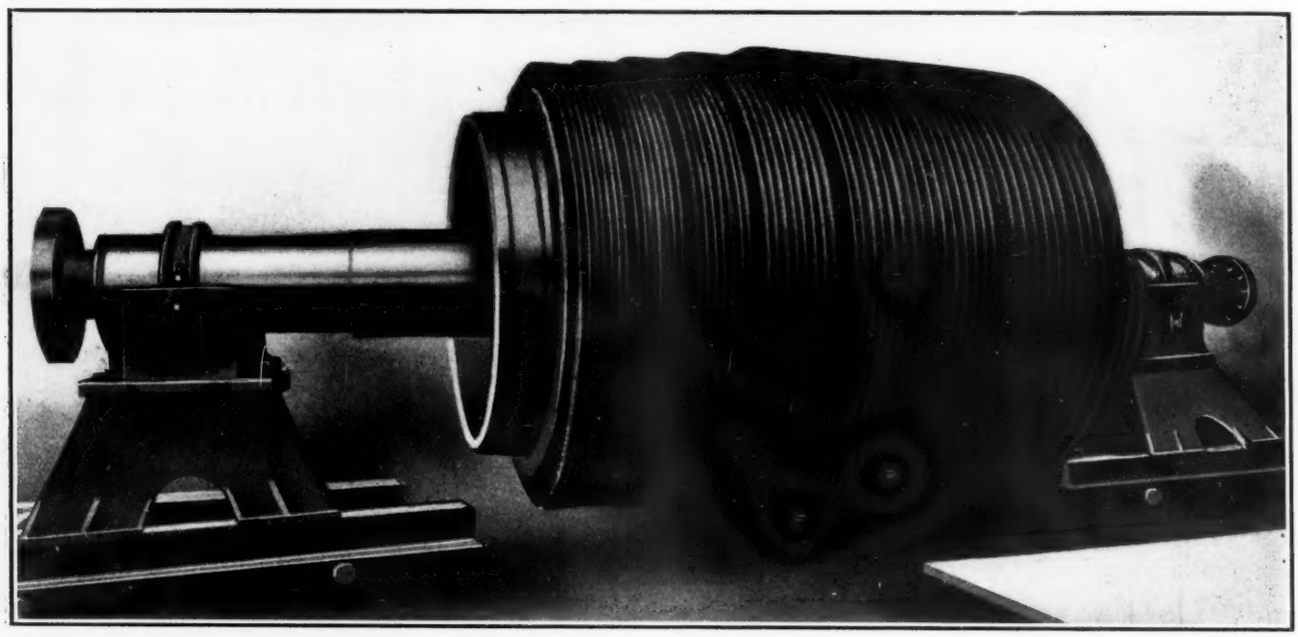
Coalite, a new fuel recently brought out in England, is the product of the partial distillation of coal, being a black and friable residue, composed in large part of volatile matter. This residue is compacted into a hard substance like coke, the process, however, being a secret one. Tests have shown that, although coalite contains a smaller number of heat units per pound than soft coal, nevertheless a much larger percentage of its heating value can be utilized, one ton of coalite being equal in heating value to one and one-half tons of bituminous coal. Its adoption as a fuel will depend largely on the price at which it can be sold, this, in turn, depending on the prices which can be realized for the by-products of distillation—gas and tar.—*The Valve World.*

Evening classes have been instituted in connection with the work of the mechanical engineering department of the Polytechnic Institute of Brooklyn, N. Y., including laboratory courses in the gas- and gasolene-engine branch and courses in machine design, mechanical drawing, heating and ventilating, mill engineering and power-plant design.

Economy Test of a 7500-Kilowatt Westinghouse-Parsons Steam Turbine

The following data include the principal results of an eight-hour economy test, made September 1, 1907, upon a Westinghouse-Parsons turbine, installed earlier in the year, at the Waterside station No. 2 of the New York Edison Company. The test was conducted entirely under the direction of J. P. Sparrow, chief engineer of the Edison company. The various arrangements were carried out in accordance with a mutual agreement between builder and operator, and the results were obtained by independent computation.

The unit tested is of standard Westinghouse construction throughout. It has a maximum rated capacity of 11,250 kilowatts, and was built to operate on 175 pounds initial steam pressure, with 28 inches vacuum and 100 degrees of superheat. Under these conditions there was guaranteed a minimum steam consumption of 15.9 pounds per kilowatt-hour at the generator terminals, with a normal speed of 750 revolutions per minute. Incidentally, the efficiency of the generator was guaranteed to be 97.8 per cent., exclusive of friction and windage, at a load corresponding to that sustained during the test. The results of the test, as shown, reveal an economy about 7.5 per cent. better than the guarantee.



ROTOR OF ONE OF THE LOW-PRESSURE TURBINES ON THE "LUSITANIA." WEIGHT, 11¾ TONS

of 4 feet 1 9/16 inches, and for a working pressure of 195 pounds per square inch.

The Turbines

The high-pressure turbine rotor drums are 96 inches in diameter, the astern drums 104 inches, and the low-pressure drums 140 inches. The turbine blades vary from 2¼ inches to 22 inches in length; for the longer blades the necessary radial and lateral stiffness is obtained by means of three rows of shrouding, in which expansion is allowed for in the same manner as in the "Carmania." The longer blades of the low-pressure turbines were bound together by two circumferential strips, laced with copper wire and soldered, and in order to prevent distortion due to the differences of expansion of the drum and the brass strip, very ingenious expansion joints have been devised. The binding strips were divided

Methods of Conducting the Test

Load—During the test period Waterside station No. 2 sustained practically all of the 25-cycle load on the system, of which the unit under test carried about 70 per cent. This load was maintained as con-

stant as possible by adjustments of the turbine governor made by the switchboard operator through a remote-control system. Between the first and the last hours of the test, the maximum variation in load was held within 4 per cent. above and below the mean. During the last hour, however, the load decreased somewhat. Previous to the test, this unit had been running on a load of 7000 kilowatts, which was increased to its test load ten minutes before the start.

Calibration—The three-phase electrical load was measured by the two-wattmeter method, using two Weston indicating wattmeters of the standard laboratory type. These instruments were calibrated at the New York Electrical Testing Laboratories immediately before and after the test. The power factor was maintained substantially at unity, and all electrical readings were taken at one-minute intervals.

Steam Consumption—As a surface condenser was used, the water rate was determined by weighing the condensed steam delivered from the condenser hot-well. This condensation was weighed in a tank mounted upon platform scales, with a reservoir above large enough to hold the condensation accumulating between the weighings. See Fig. 1. These weighings of from 12,000 to 13,000 pounds each were made at intervals of five minutes.

Gland Leakage—By the loop method of connecting the gland-water supply, shown in Fig. 1, the necessity for correcting condensation by an amount equivalent to the weight of the gland water used was avoided. It will be noticed that a continuous gland-water circuit was used entirely outside of the weighing apparatus, and that all overflow from the standpipe returned to the hot-well delivery.

Condenser Leakage—As the circulating water was quite salt, any condenser leakage could be detected immediately by the salinity of the condensed steam, which should be pure distilled water. On this account, condenser leakage was determined entirely by chemical analysis, employing the silver-nitrate test with a suitable color indicator. This method proved extremely sensitive, and possessed a decided advantage over the ordinary method of weighing the leakage accumulating during a definite period when the condenser is idle and under full vacuum. As samples of circulating water and condensed steam could be taken at the same time, this method made it possible to discover any change in the rate of condenser leakage occurring during the test, while the method of weighing described provided only an average result during the period.

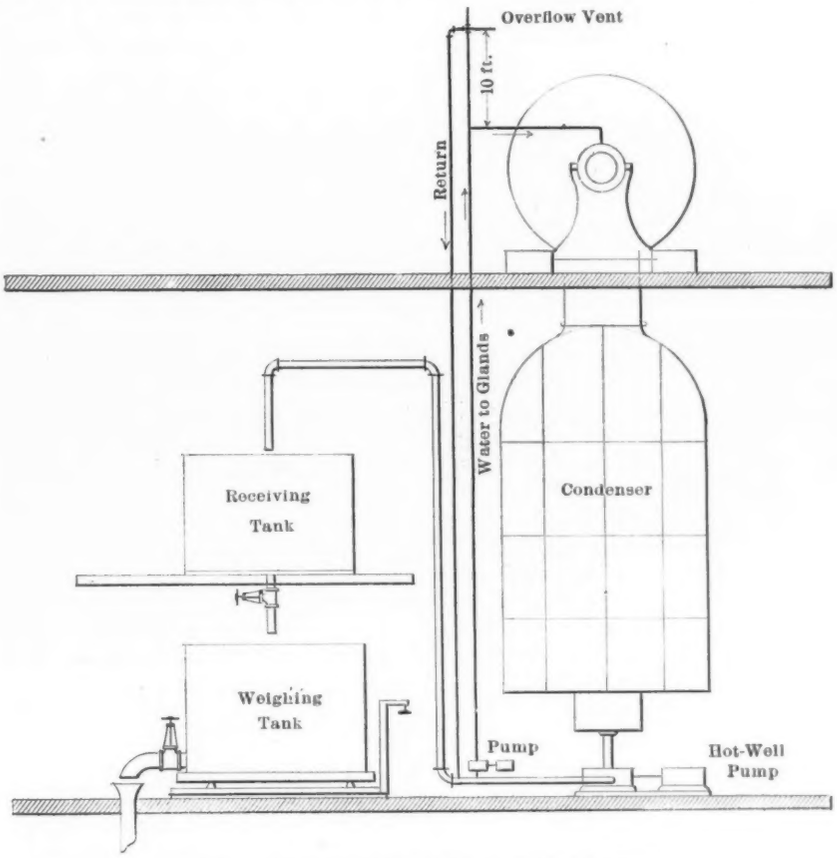


FIG. 1. METHOD OF MEASURING CONDENSATION

Hot-well Correction—In this condensing plant, the delivery of the hot-well pump is automatically controlled by a float-valve in the interior of the hot-well. This maintains the water level therein at a practically constant point, and hence no correction had to be made for any difference in the level of the water in the hot-well before and after the test.

Steam Supply—Steam pressures and temperatures were measured close to the turbine throttle. As usual, the degree of superheat was obtained by subtracting from the actual steam temperature the temperature of saturated steam at the corresponding pressure carried at the time. All gages and thermometers were calibrated prior to the test at the United States Testing Bureau. It will be noticed that both the pressure and the superheat were somewhat below the requirements of the guarantee.

Vacuum—The vacuum was measured directly at the turbine exhaust by means of a mercury column with a barometer alongside for reducing to the standard barometer of 30 inches. This also obviated the necessity for any temperature correction between the two mercury columns. During the test the vacuum was not maintained quite up to normal.

Results of Test

The following data represent the results of the test, calculated for the conditions as actually run; i.e., corrected for instrumental errors only:

Duration of test—from 9:30 a.m. to 5:30 p.m.
Average steam pressure at throttle, pounds per square inch gage, 177.5.
Average superheat at throttle, degrees Fahrenheit, 95.74.
Average vacuum (referred to 30 inches barometer), inches mercury, 27.31.
Average load on generator, kilowatts, 9830.48.
Average steam consumption, as tested, pounds per kilowatt-hour, 15.15.

Owing to the departure, during the test, from the specific operating conditions upon which guarantees were based, it was necessary to correct the observed results as follows: Pressure (2.5 pounds high)—correction, 0.25; vacuum (0.69 inch low)—correction, 1.84 per cent.; superheat (4.26 degrees low)—correction, 0.29 per cent. These corrections were mutually agreed upon previous to the test, as being fair to this type of turbine. When applied to the observed steam consumption given above, the following results, referred to the contract conditions, are obtained: Average corrected water rate, during eight-hour test, 14.85 pounds per kilowatt-hour; guaranteed water rate, 15.9 pounds per kilowatt-hour.

The accompanying chart, Fig. 2, is interesting as a check upon the average figures presented, the results being divided into hourly periods, as shown. Here it will be noticed that the load was considerably lower during the first and last hour than during the main part of the test. Neglecting, therefore, these two hours and considering only the six-hour period from 10:30 a.m. to 4:30 p.m., the results are as follows:

Average corrected water rate, 14.8 pounds per kilowatt-hour.
Equivalent water rate, 10.65 pounds per brake horse-power-hour.
Equivalent water rate, 9.8 pounds per indicated horse-power-hour.

The two latter quantities are determined by applying conversion factors for generator efficiency and for internal losses.

In connection with the test, a noteworthy agreement exists between the results noted and those previously obtained from tests of machines of similar design installed in the Manhattan station of the Interborough Rapid Transit Company, New York, and the Long Island City station of the Pennsylvania railroad. At the same loads and reduced to equivalent operating conditions, the performance of the machines is almost identical.

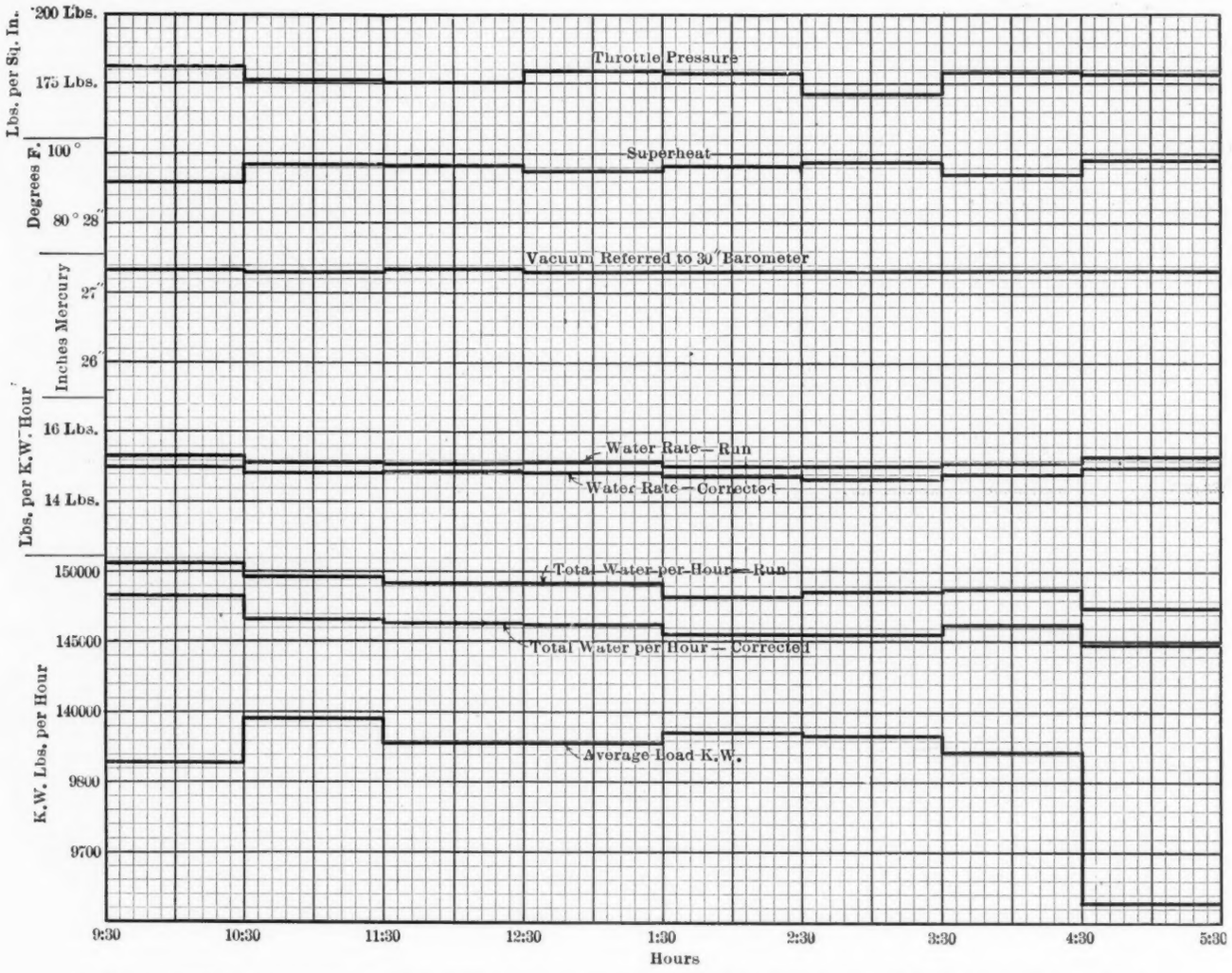


FIG. 2. HOURLY LOG OF NEW YORK EDISON ECONOMY TEST OF A 7500-KILOWATT WESTINGHOUSE-PARSONS TURBINE

A despatch from Hazleton, Penn., states that on account of the great demand for the steam sizes of coal throughout the eastern section of the country the washeries in the anthracite field are working as steadily as the big collieries. Nearly every coal company has one or more washeries at work. The washeries prepare for market the huge mountains of culm that were considered useless in the early days of mining. They are becoming more valuable as the virgin coal gets scarcer.

Boiler Explosion at Holland, Tex.

On September 6 last a boiler explosion at a gin plant at Holland, Tex., resulted in injuring five persons, two fatally, and damaging property to the amount of $10,000. It was a two-sheet horizontal boiler, without girth seams, containing sixty-four 3-inch tubes. A correspondent informs us that the initial rupture was apparently in proximity to the top rivets at the front end, whence extended two ruptures the entire length of the boiler, tearing out a strip four feet wide at one end and one foot wide at the other, and including the dome. This section, weighing 500 or 600 pounds, was blown 300 feet away, while some of the tubes were found considerably farther off. The longitudinal seams were found to be in good condition.

It was stated that a new gage and a new safety valve had been installed a short time before, but that the gage never indicated more than 70 pounds pressure, however much the boiler was forced, although the safety valve was being continually tightened.

Bare Steam Pipes Eat Up Coal

How often does one find in large installations long lengths of uncovered steam pipes eating into the coal pile as a result of continuous radiation losses. Few realize how great the difference really is. A 50-foot length of uncovered four-inch pipe would seem to many engineers in charge of a power installation a trifling detail, hardly worth troubling about for any possible economy that could result from coating it with non-conducting composition. And yet, with steam at 100 pounds pressure, the condensation in such a length would be not less than 40 pounds per hour, or over a ton per week of 60 hours, and with 50 working weeks would represent on a very modest evaporative basis 6 tons of coal per annum, the cost of which would defray the expense of covering several times over. We have taken a comparatively insignificant illustration. In actual practice it is no uncommon thing to see power plants where 10 or 20 times the amount of uncovered heating surface we have mentioned wastes its radiation on the desert air.—*The Mechanical Engineer.*

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

"Feeding Steam Boilers"

On page 636 of the September number, Mr. Wakeman evidently makes an error (unintentionally, of course) in his statements that, "No logical reason can be found in this case at least, and probably not in any other, for saying that the best fire causes more water to go to the other boiler. These boilers are connected by large steam pipes, making it impossible for the pressure to be greater in one than the other." Twelve years ago I wrote, "The water will enter with the most difficulty into the boiler which is steaming hardest," and I was laughed at for saying it, because "everybody knew that."

A pair of boilers on a steamboat at Buffalo frequently showed 10 pounds difference on the gages, sometimes one and sometimes the other being the higher; although they were connected by an extra equalizer pipe of 2½ inches diameter. Again, twin boilers over a single furnace, which was built wide enough for both, were fed by a tee branch with no checks between, and by means of a tee in the steam main delivered steam to one engine, thus making equalizers of both the steam and water pipes. The glass gages, however, frequently showed 3 inches difference of water level. The engineer was frightened, but I told him to keep his fire even, and to fire hottest under the fullest boiler. He answered that he had already found out that that was the only thing to do, and that it drove the water from that boiler into the other. He was afraid, however, that the unequal fire would drive out *all* the water and burn the boiler. Yet again: In a case where seven 150-horse-power boilers were fed from one line, it was found that the boilers did not take water alike, nor with uniform differentiation, but the difference varied with the firing and other conditions.

A sober second thought will plainly show that the greatest amount of boiling will cause the greatest internal resistance; also, that with two supplies of water, or of steam, flowing through one tee, the different velocities will cause different pressures, if slight, in the two portions—but the result depends upon conditions which cannot be ascertained except from observation.

F. R. WILLIAMS.

Syracuse, N. Y.

Suggestion Wanted for an Engine-room Ceiling

Our engine room is in a one-story annex, about 19 feet high, which has a reinforced concrete roof, with tar paper, pitch and sand on top. The under side of the roof, which is supported on cross beams, forms the ceiling of the engine room. In winter while the temperature outside ranges from 0 to —30 degrees, and the temperature inside averages about 65, the roof sweats so that the dynamos have to be protected by housing covered with oilcloth. This coming winter we propose to put in a ceiling, leaving a space between it and the concrete roof about 10 inches in depth. The ceiling must be fireproof and we hardly know what material to use or how to use it. Can any POWER reader help out?

JOHN CARROLL.

Winnipeg, Man.

Paralleling Alternators

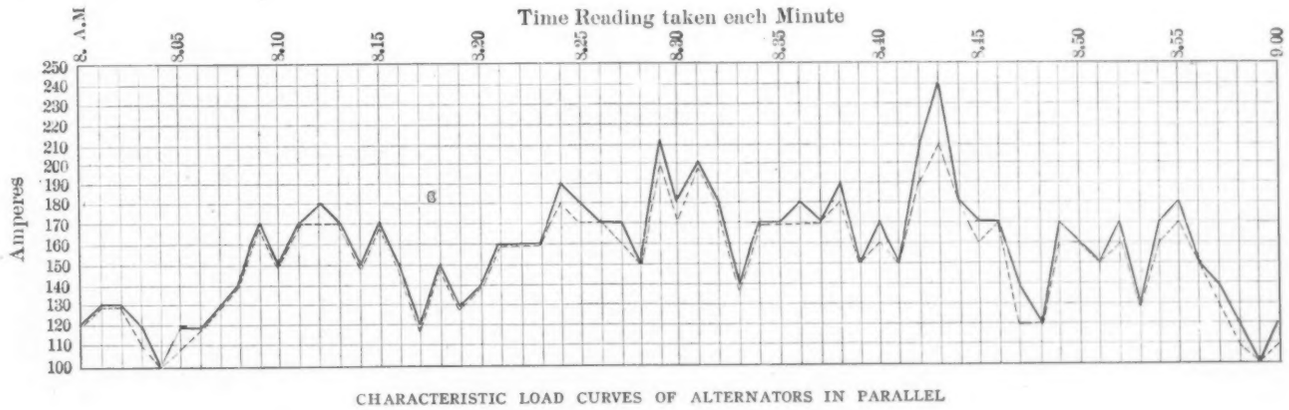
From time to time interesting articles have appeared about the parallel operation of alternators. In this plant are two 1000-kilowatt machines which furnish power for an interurban railway. One is driven by a cross-compound direct-connected engine having a 50-ton fly-wheel and running at 94 revolutions per minute. The generator has 32 field-magnet poles. The prime mover of the other unit is a Curtis steam turbine running at 1500 revolutions per minute; the generator is a bipolar machine. Each machine delivers polyphase currents at 2300 volts and 25 cycles.

The engine has double eccentrics and a fly-ball governor controls the cut-off for both cylinders, regulation being by means of a hand-screw adjustment. The turbine has an hydraulically operated governor.

The accompanying chart shows a characteristic load curve of each machine, the unbroken line representing the engine and the dotted line the turbine. Minute readings were taken for an hour and the curves plotted from the readings. They represent an every-day condition.

In paralleling, the normal voltage is raised on each and the machines synchronized. Then the rheostats are adjusted until the power factors are equalized, as shown by the power-factor indicators with which the machines are equipped. Then the governors are adjusted until each machine takes as nearly as possible its share of the load.

In studying the chart it will be seen that at times the engine takes more than



CHARACTERISTIC LOAD CURVES OF ALTERNATORS IN PARALLEL

its share of load; this is believed to be due to the weight and momentum of the fly-wheel. For instance, at 8:04, 8:05 and 8:06 the demand for power was increased and the fly-wheel absorbed most of the shock, allowing the turbine to come up gradually. Again, at 8:11, 8:12 and 8:13 the engine took entire care of the increased demand. Although of radically different construction, these machines give very good results operating in parallel. There has never been any trouble on the score of "hunting."

J. W. M.

Riverton, Ill.

Blow-down Valves on Water Columns

On page 630 of the September number Thomas Sheehan illustrates the connections on a boiler and mentions that the steam had been shut off at the stop-valve and when he opened it again there was trouble. From the sketch, it is evident there was no drain at the stop-valve; the pipe had collected water and he had a nice case of water hammer.

In such a case, if there is room for the water, it is the safer plan to open the valve quickly, get rid of the water, and then close it. If this course would cause more damage than to have the valve split open, then close the valve and run. Mr. Sheehan was fortunate that the hammering stopped before it did any damage.

W. E. Crane.

Boston, Mass.

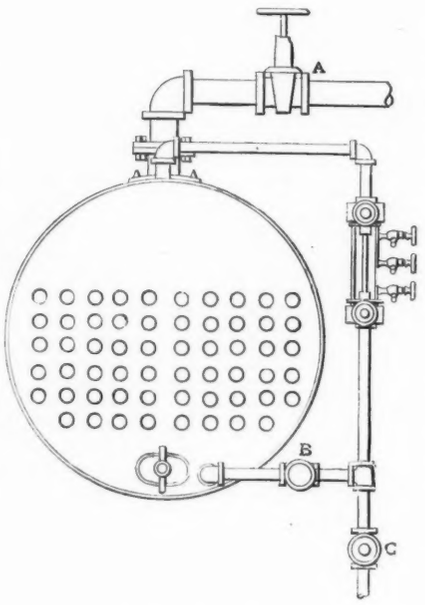
In regard to Mr. Sheehan's query, I can say that more than once I have done the very thing that the examiner claims is the proper way to blow up a boiler, without noticing any such effect.

The plant in which I am employed as engineer has two boilers. When the electric-light engine is put in service, both boilers are used, but during the day one boiler is sufficient to run the plant. A few minutes before shutting down the dynamo engine the fire is allowed to burn down under the small boiler; next, the feed-water valve is shut; then when the boiler has about half a gage of water and as soon as fire is low enough, both ash-pan and stack dampers are closed, leaving the main steam valve open to the boiler. On several occasions the feed-water valve has leaked so much water into the boiler that it was necessary to blow the boiler down two or three inches before putting in fire. The blow-off is not connected to the water column or safety valve, but is located at the bottom of the boiler. Mr. Sheehan does not state whether the boiler had any pressure on when he went up to open the main steam valve, but, judging from the diagram, he must have had to "kill" the boiler to put in the valve. In such case he opened the main steam valve into a cold boiler and it is no wonder that everything began to jump. That is certainly an ideal way to blow up a boiler—one that should give quick results.

S. F. Cottrell.

Skagway, Alaska.

I would like to ask Mr. Sheehan what the idea was in cutting in the boiler under consideration before it had generated its own steam. The usual practice is to get the pressure equal, or nearly so, before



LOCATION OF MR. SHEEHAN'S BLOW-DOWN VALVE

cutting in an idle boiler, and even then it has to be done with the utmost caution in order to equalize the pressure by degrees. But as I understand Mr. Sheehan's letter, it seems that the idle boilers were used as receivers, and why they should be so used I cannot conceive.

In regard to the examiner's contention that an explosion would take place by opening the blow-off valve before the idle boiler was properly cut out, I am sure that no particular harm would be done, although the proceeding would be wrong.

If Mr. Sheehan will read the editorial on "Rupture of Boilers from Impact," published in May, 1904, Power, page 307, he will get a good idea why it was that such a commotion took place when he opened the valve *A*. Probably a partial vacuum had been created in the idle boiler and the steam had just so much greater velocity.

Albert L. Anderson.

Douglas, Alaska.

If I understand Mr. Sheehan correctly, he shut the boiler off from the main steam line by closing the valve *A*. He then let the steam pressure down (he does not state how) and, after completing his changes, he went up and opened the valve *A*, letting steam at a high temperature and regular boiler pressure into a comparatively cold boiler. I think the rapid expansion of the boiler fully accounts for the commotion he speaks of. I have seen an eight-inch steam line exploded by having high-pressure steam suddenly turned into it. If a boiler has been cut out from a battery, it should be fired up and the steam brought to the same pressure as that in the other boilers of the battery. The boiler should then be *slowly* cut in.

In some electric-light plants where the load is light during the day, it is customary, although probably not economical, to pull the fires on the boilers not needed for the day load, but not shut them off from the steam line until night, when they are again fired up. If the feed-valves on such boilers leak a little, they will fill up very quickly, the condensation helping, of course, and under such conditions I have blown boilers down several times a day without any effect such as Mr. Sheehan describes.

Mr. Sheehan's water column should have had a valve in the steam connection between the column and the boiler, so that the column could be cut out and drained when there was pressure on the boiler.

H. L. Turner.

Goldfield, Colo.

Thomas Sheehan's experience is only what anyone may have by doing the same trick with boilers piped and managed the same way. When intercepting valves are placed between the boiler and the water column, they should be placed on both the steam and the water connections. This gives an opportunity to shut the column off and make a necessary repair while the boiler is under steam. When the fires are drawn from one or more boilers of a battery, as soon as the furnace has cooled down enough to prevent the boiler blowing off at the safety valve, it should be cut out altogether; and certainly before it has ceased to generate steam and commenced to fill by condensation from the steam line.

R. A. G

Dauphin, Man.

Regarding Mr. Sheehan's query, if the boiler is full of water and connected by the steam main to the rest of the battery (that is, in working order), then the "dead" boiler becomes the same as a dead pipe-end, and if the blow-off is opened, the steam rushes in from the live boiler

and begins to heat the cold water in the dead boiler, and water hammer becomes so violent that there is danger of rupture. At all events, if the boiler is not blown up, it will be strained. By all means, a cold boiler connected to a working boiler should never be blown off; cut it out first.

J. F. SUMMERS.

Durango, Colo.

Referring to Mr. Sheehan's sketch, no valve is shown on the upper connecting pipe of the column and this, in my opinion, is a poor way to connect a water column. It is stated that there is a pressure on the boiler equal to that on those in operation. Now, even if the valves *B* and *A* are closed it will take some hours for the pressure to drop to zero, so that the valve *C* can be changed; and even supposing the boiler to be completely filled with water, the pressure will have to be reduced to zero.

It is a very dangerous practice to cut in a boiler in which there is no pressure with one under high pressure. There is very little doubt that this is what caused the commotion related. Yet I cannot understand how closing the valve *C* could make such a difference in results obtained.

As to the second query, if I understand it rightly, I am inclined to agree with the four engineers referred to that there would be no danger in blowing down the boiler, after first closing the steam valve, care being taken to open and close the blow-off slowly.

Where the danger might come in, in letting a boiler fill right up with water, would be the liability of water going over to an engine; and should the full boiler be the first one on the line, next to the engine, the danger would be greater than if it were the last, or end one. It would be possible for so much water to go over that an ordinary separator would not be able to take care of it, and an engine wreck would result.

JAMES E. NOBLE.

Toronto, Can.

Mr. Sheehan's experience in connection with turning steam into a dead boiler reminds me that I have been there myself, and I believe that a safe rule upon such occasions is, "Don't do it." Some time ago we found it necessary to increase our boiler capacity, and put in two 54-inch by 16-foot return-tubular boilers. We had finished the installation and a slow fire was built under them for drying out. A large flow of water was unexpectedly cut (this being in a mining plant), which made it necessary to speed up the pumps. This meant more steam, which could not be furnished except through the new boilers, for if we did not get it we should lose the pumps and have to shut down. Under these circumstances it was determined to take a chance, and warm up the boilers by turning in steam from the header. The "old man," knowing the danger of this, attended to it himself, while I was stationed to watch the gage. He had been at the valve some 15 minutes, it being open barely a crack (in fact, you could hardly hear the steam passing through), and he had just asked me how the gage stood. I answered, "Ten pounds"—at which everything seemed to let go, including the "old man"; the fire-doors flew open, and we left, not knowing what was coming next. Nothing else happened, however. We found that the circular seam on the second course of the shell near the bridge wall had ripped from hole to hole for nearly one-half the circumference of the boiler, the shell being entirely separated from the next course, with the rivets intact. Nothing else was disturbed; the walls were not even cracked. I had my hand on the shell just before and found it barely warm (below the water line). There was less than two gages of water in the boiler at the time. The other gage was not stuck and both registered the same. It could hardly be called an explosion, it was more like the effect of a black-powder blast some distance away, or a concussion of air. If there is a safe way of warming up a boiler with steam I should like to learn of it, as it would be very convenient at times.

INQUIRER.

St. Elmo, Colo.

Precautions in Using Portable Electric Lamps

When portable electric lamps are used inside boilers, or on machinery, a good deal of trouble is often caused by the lamp-holder getting "alive," due to insulation wearing off the flexible cord inside the fitting, or moisture getting in. To get hold of a "live" lamp on a 200-volt circuit, while standing on iron floor-plates or working inside a boiler is, to say the least, decidedly unpleasant, and in some cases has caused serious injury. As such faults are by no means uncommon, the writer took the precaution of having all portable leads made up of wire-armored flexible cord, one end of the wire armoring being connected to the lamp-holder and the other end grounded. In case of leakage in the fitting, this insures the fuse being blown, and avoids all risk of shock to the person holding it. Armored wire also lasts much longer than ordinary flexible cord and its adoption would pay for this reason alone.

When the wires leading to the wall plugs are run in grounded metal conduit, and metal plug-boxes are used, it is an easy matter to screw a piece of L-shaped springy brass onto the plug-box in such a way that the end of the wire armoring attached to the plug of the flexible cord shall make contact with it and insure a proper ground.

If this cannot be done, the flexible cord can be given a turn around any metallic portion of the machine or boiler on which a man is working; when the same condition will be effected.

A. W. EMPSON.

London, England.

"Who Can Explain This Phenomenon?"

In regard to "Inquirer's" query on page 556 of the August number, I believe the following will explain the grouping of the balls. In the case where one ball is drawn back and allowed to spring against the others, ball No. 1 would strike No. 2 and impart to it its momentum; No. 2 would go ahead with the same velocity, while No. 1 would remain stationary, the action being like that of two billiard balls. No. 2 would strike No. 3, which would strike No. 4, and so on to the end. No. 6 having no ball to strike, would fly away from the group, and on the rebound would set up a reaction and this would cause No. 1 to fly to the left.

Where two balls are drawn back and released the action is similar, only as two balls are used they act as one weight, and the shock induced by the heavier weight causes the two balls at the opposite end to fly away from the group, as the impluse is not all absorbed by the end ball alone, as was the case when one ball was drawn back. With three balls the result is the same, the three balls acting as a single weight and communicating their combined action to the other three balls.

The grouping of the five-ball combination is rather peculiar but a little study shows that the same rule holds good. The five balls are not stopped when they strike the sixth ball, but are slowed up by an amount equal to that required to impart to the sixth ball the same velocity as that at which the five balls were moving. The sixth ball travels faster and moves away from the five-ball group. When it comes back the shock it imparts to the group travels through the balls until it comes to No. 1, which bounces off, as it were.

C. MELVILLE STRANGHAN.

Oakville, Wash.

Lead and tin can be obtained very pure. Good brands of commercial lead contain 99.95 per cent. lead and is often even purer. Lead is the purest metal which is made commercially. Good brands of tin contain 99.8 per cent. pure tin.

Cause of Explosion Waves in Crude-oil Engines

The article by H. Addison Johnston, on page 588 of the September number, treating of indicator diagrams from a Canadian crude-oil engine, was very interesting. I notice, however, that the author did not publish his theory of the causes of the explosion waves shown in some diagrams. It has occurred to me that other readers may be interested in the cause, so I will give, for what it is worth, a theory that has been advanced in similar cases.

It has been found that when a liquid hydrocarbon is sprayed into an intensely hot chamber, explosion waves are produced unless the fuel drops are under a certain size; so, if an explosion wave is found in such a case, the remedy is to produce a finer spray. This phenomenon is found to be connected with the spheroidal state of the fuel.

F. E. WATTS.

Detroit, Mich.

"A Packing and Temper Saver"

On page 619 of the September number, under the caption of "A Packing and Temper Saver," is a stuffing-box device which is right enough but rather unhandy, for when it comes to tightening the gland it will necessitate the removal of the gland *and* the ferrules, and the latter will have to be shortened, unless different sizes are always kept on hand.

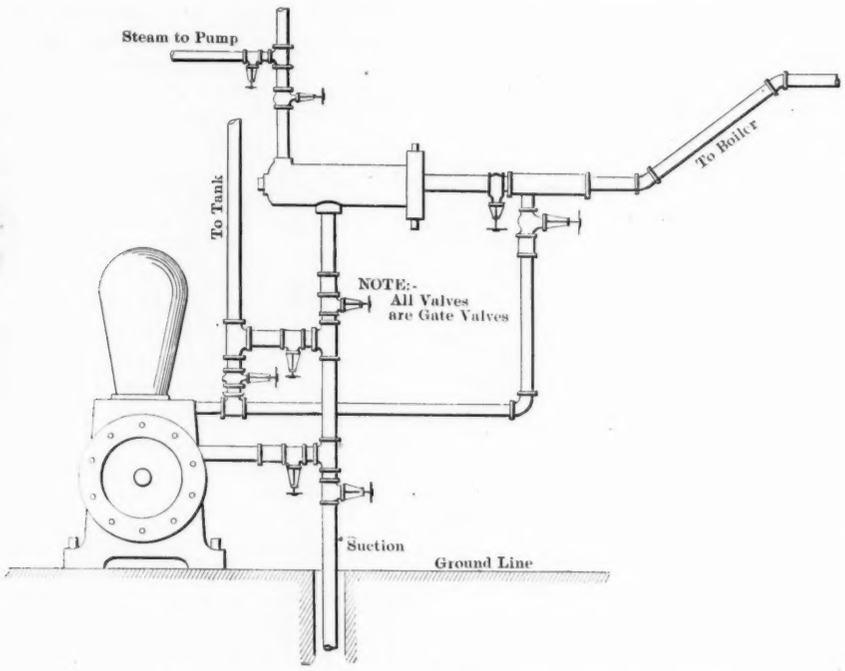
I saw a stuffing-box device on an old engine, which I have used to advantage. It is practically the same as the device shown on page 619, only instead of using ferrules the threads on the stud-bolts are cut a little longer and a nut inserted on the part incased by the ferrule. This nut acts as a jam-nut, keeping the outer nut from working loose, and it prevents the stud-bolt from working loose, if tightened properly. It also keeps the gland in position.

L. HAWKINS.

Reading, Penn.

"Piping a Steam Pump and an Injector"

"Beginner's" arrangement on page 559 of the August number seems very compact, but I think it could be improved. The discharge from an injector should be as nearly straight as possible, and all bends should be as easy as possible. I therefore suggest that the tee piece of the injector delivery should be turned with its branch looking down, as shown in the accompanying sketch. This gives a straight discharge and if it is necessary to rise afterward it should be done by means of easy bends. I have eliminated the cast elbows made by "Beginner," as I consider they offer too much resistance to the flow, and also entail extra joints to be kept tight. Cross-valves offer too much resistance, which outweighs their convenience. I have altered the positions of some of the valves to save joints.



D. K.'S SUGGESTION FOR PIPING A STEAM PUMP AND AN INJECTOR

D. K.

London, Eng.

The H & M Stop and Isolating Valve

We claim as one of the special features of our valve that it is self-contained and requires no auxiliary pipe nor pilot valve. In the article by C. C. Major, in which mention is made of our valve, on page 683 of the October number, it is stated that the valves "may also be operated by opening a valve in an emergency pipe which may be carried to any convenient point from the steam main between the valve and engine."

This statement is radically wrong, and we cannot understand why the writer of the article made such a mistake. We wish you would use every effort in your power to correct this error. Our valves *can* be made to close instantaneously from a distance, not through any pipes, however, but by a mechanical appliance or by an electrical push-button device.

H. & M. VALVE COMPANY,
J. A. CARTWRIGHT, *Manager*.

New York City.

How to Tell Whether Boiler Has Been Blown Down

With reference to the inquiry on page 701 of the October number, as to a method of ascertaining whether a boiler has been blown down at regular intervals, perhaps the method I employ may be of use to T. B. Rice & Sons Company and other POWER readers.

A pipe connected to the blow-off leads from the boiler through a room in one of the buildings, to the roof, where it has a free outlet. When the boiler is blown down part of the steam must pass through this pipe. In the room referred to a section of the pipe is inclosed in a wooden box in which is a maximum thermometer. When the boiler is blown down, the heat of the steam passing through the pipe heats the confined space in which the thermometer is located; consequently when the thermometer indicates an abnormal temperature, it shows that the boiler has been blown down. The thermometer may then be reset and it is ready for the next blowing down.

The boiler is blown down three times a week, and sufficient steam passes through the pipe to raise the thermometer to about 120 degrees Fahrenheit, the room temperature rarely exceeding 90 degrees; so that, notwithstanding that the blowing down must always be done at night, we can invariably tell whether or not the fireman has attended to this very important duty.

TIMOTHY D. GILES.

Hoboken, N J.

Advantages of the Poppet-valve Engine

During the last two or three years a great deal has been written regarding gas engines and steam turbines, and these two prime movers are going to become very popular. Nevertheless, for nearly one hundred years the reciprocating engine has been without any notable competitor and has won the highest confidence of the industrial world by reliable service and by simplicity of construction and operation.

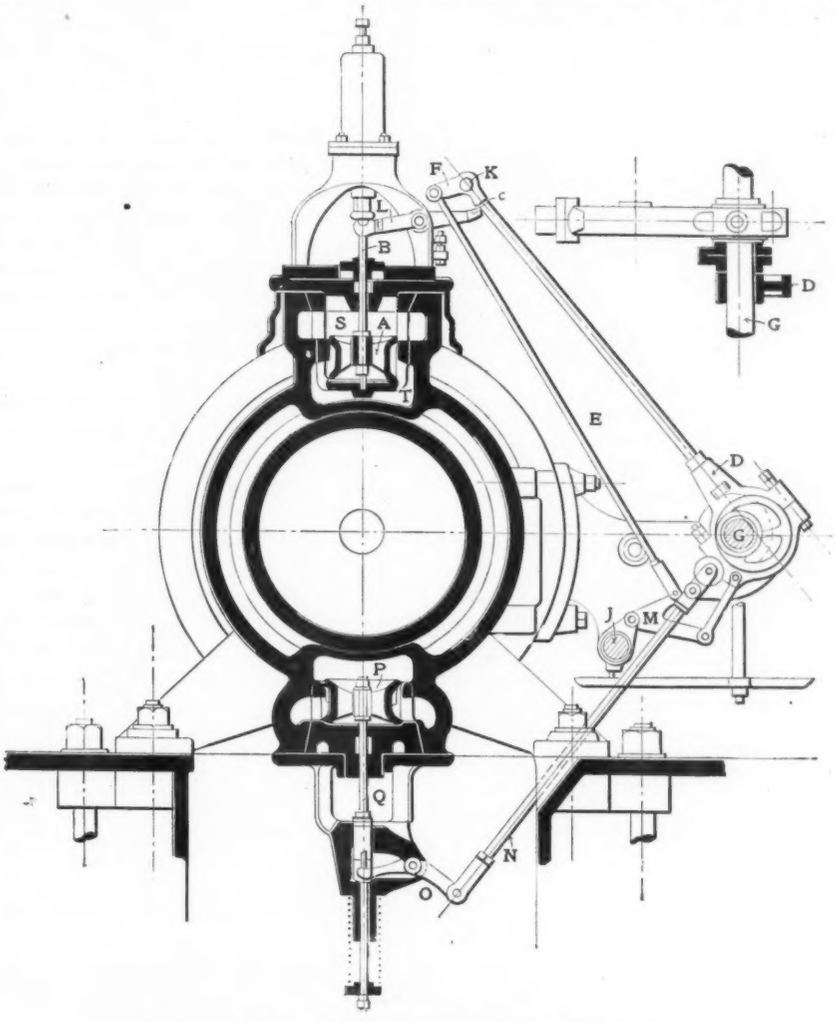


FIG. 1. SECTION THROUGH A BALANCED-VALVE ENGINE

In this country, the Corliss engine always has found purchasers and, therefore, manufacturers. The confidence in this type of engine is very reasonable, as the simple construction guarantees reliability in operation. As long as this engine is run with moderate velocity it is not liable to frequent repairs, as no parts are exposed to great wear and tear. Furthermore, it is possible to adjust the valve-rods so exactly as to get good steam distribution and good steam economy.

In Europe, however, and especially in Germany and Switzerland, the Corliss engine could not hold its own after the "balanced valve" had proved its usefulness. In 1867 the Sulzer engine came on the market and soon a new era of steam-engine design was in sight, and the balanced-valve engine began to be regarded as capable of affording the best steam economy.

Fig. 1 is a sectional view through a balanced-valve engine built by Gebrueder Sulzer, of Winterthur. The valve-shaft *G* is parallel to the center line of the cylinder and is driven by bevel gear from the crank-shaft. An eccentric *D* lifts the valve *A* by means of the lever *L* and the valve-rod *B*. The eccentric is not directly connected with the lever *L*, but the motion is transmitted by the bell-crank *F* on the lower end of which is a sliding surface and a hooker-plate with cut-off edges *c*. The bell-crank *F* turns around the pin *K* and the position of the cut-off end is influenced by the governor, whose motions are transmitted by the shaft *J*, the bent lever *M* and the rod *E*. Steam enters the space *S*, and passes through the valve to the space *T*, which is connected with one end of the cylinder.

The exhaust valve *P* is operated by a cam actuated by the rod *N*, the lever *O* and the valve-rod *Q*. The illustration shows one of the earliest and most popular designs of this engine. Since the time it was built there have been numerous construction changes. For instance, instead of an ordinary fly-ball governor, a shaft governor is often used. It is mounted on the valve-shaft and connected with the eccentrics directly.

The good steam economy of the balanced-valve engine is due, first, to the tightness of the valves, which helps to keep the seats clean and avoids the necessity of frequent re-grinding. With tight valves all of the steam enters the cylinder with the highest pressure and temperature and performs its work nearly according to the Carnot cycle.

Secondly, the section of the valve can be made as large as necessary to give a horizontal admission and exhaust line; so the diagram has the greatest surface. Fig. 2 shows a diagram of a balanced-valve engine. It is as perfect as it possibly can be.

Thirdly, an exact cut-off influenced by a sensitive governor also enhances steam economy. The influence of the governor is so perfect in a modern engine that the diagram is just as exact with small load as with full or overload.

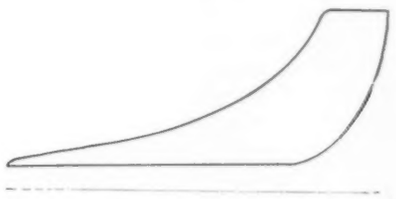


FIG. 2

The arrangement of the valve-shaft parallel to the center line of the cylinder affords several advantages, also. It is very easy to oversee the valve-rods, eccentrics and cams. Every valve has an independent drive and the operation of one does not interfere with another, so that the adjustment of the rods is very easy. Difference of length of the units has not the least influence on the operation of the valves, since they are driven by a valve-shaft.

The valves are so nearly balanced that the power required to lift them is very small; therefore, the rods can be made light. Wear and tear of valves and drive is very slight, and the velocity of all moving parts is so low that even with a high number of revolutions the engines are practically noiseless. For many years there was no demand for high velocity, but as soon as the electrical engineers asked that the velocity of prime movers be increased, the steam-engine manufacturers found that the balanced-valve engine could easily be operated at from 100 to 130 revolutions per minute, and even 200 revolutions per minute is not infrequent.

The competition occasioned by the advent of gas engines and steam turbines forced the manufacturers to adopt superheated steam to secure still greater steam economy. For high temperature the balanced valve is the most reliable means of distribution. Expansion by heat does not deform this valve, as it is symmetrical, and it keeps tight even in a temperature of 570 degrees Fahrenheit, which is the highest temperature regularly used in service.

The general arrangement of the balanced-valve engine is very pleasing and the almost noiseless running makes the operation easy and agreeable.

For all these reasons the balanced-valve engine has won great popularity in Europe. There the balanced valve is also used for vertical engines, and even some locomotives and locomobiles have been fitted with it.

LEO KRESSER.

Passaic, N. J.

"How Should Globe Valves Be Placed?"

In answer to S. Wrench, who asks, on page 637 of the September number, how globe valves should be placed, I should say that all globe or angle valves for steam or gas pressures should be placed so that the pressure comes on the under side of the disk. The main reason is that when the pressure is below the disk, the valve will almost invariably seat better, as, when the steam enters above the disk and the valve is nearly seated, the rushing steam has a tendency to blow a little harder through one side, owing to the whirling motion it attains, and this causes the disk to seat improperly by one side seating a little ahead of the other.

Some engineers argue that the pressure helps to press the disk down on the valve seat when the pressure is above the disk, but if the valve leaks when turned down as tightly as it can be turned by the handle, it is time to regrind the valve, or put in a new disk, as the case may be.

I have had several experiences with the disk becoming detached from the stem, and in one case it was in the water-supply pipe between the feed-pump and the boiler, or, rather, between the check-valve and the boiler. It immediately blew the packing out of the feed-pump, and it being the only source of supply to the boiler, we had to shut down the plant for nearly a whole day, so the valve could be repaired.

Had the valve been placed the other way the disk would have acted as a check-valve and we could have kept running until a convenient time for repairing.

M. JOHNSON.

Emmetsburg, Iowa.

S. Wrench wants to know how a globe valve should be placed; that is, should the pressure be on top of or underneath the disk-holder when the valve is shut? It should be underneath if for no other reason than that the stem can be easily packed. Then, too, when the pressure is underneath, if the disk-holder has a little play on the stem, one does not have to turn the wheel nearly around before the disk begins to lift off its seat.

Regarding the stop-valves placed between the boilers of a battery and a header common to all, on which side of the valves is the pressure, on the boiler side or on the header side? How should globe valves be placed there?

R. MANLY ORR.

Brantford, Ont.

On page 637 of the September number S. Wrench discusses the old question of how globe valves should be placed. In this locality they are almost always placed so that the steam enters below the disk. When they are so placed, they can be closed and packed when there is pressure on the line, but when they are placed with the steam entering on top of the disk they cannot be packed as long as there is any pressure on them.

Globe or angle valves in the pipe connecting the boiler to the main steam line should be placed so that the steam from the boiler will enter above the disk. Then when that boiler is cut out, they can be packed. If they are placed the other way, the whole plant has to be shut down before they can be packed.

H. L. TURNER.

Goldfield, Colo.

"Pumping Hot Water Is Different from Pumping Cold Water"

I was much interested in Mr. McGahey's letter on page 633 of the September number on pumping hot water, because I used to have charge of pumps which handled water of from 200 to 210 degrees temperature. Our feed pressure was always from two to ten pounds in excess of the boiler pressure, but until we gained knowledge from experience hammering of the pump caused much trouble.

There should be a tee in the suction as close to the pump as possible, with the branch looking upward. From this branch, and preferably of the same size as the suction, a riser should extend two or three feet above the surface of the water in the heater. This will form a trap for all vapor, and the pump will get solid water. (This idea was obtained from a catalog of Cochrane heaters.)

It is absolutely necessary with a single-acting pump to keep a good supply of air in the discharge air chamber or the check-valves in the boiler room will be very noisy. This air chamber should be larger on this service than on cold water. The glands must be kept tight enough not to leak air. This may sound like unnecessary advice, but if the pump runs pretty fast it will sometimes take air when it will not leak water, and then, of course, as the cylinder does not fill, the plunger jumps until it catches the water, when it stops with a bang. This air has a nasty habit of remaining in the chamber and every suction stroke adds to it, until in a very short while the plunger is jumping a half stroke, or more, and something is very apt to get broken.

In my opinion, the pump for this service should be of the outside-packed plunger type, with valves of composition metal, and the suction valves without springs or too much lift. The packing must be of a kind that will remain soft in service. That which I used would last from six to eight months on an 8-inch plunger and remained soft until worn out. Should a packing be used which hardens in service, the plungers will probably be badly cut before discovery, especially if they happen to be made of an iron which softens under the action of such hot water. The writer at one time took out a set of plungers which could be cut into for a depth of ⅜ of an inch just like cheese, and although exposed to the air three or four months, the packing did not harden.

Mr. McGahey says, "hot water should always be above the suction." This is very true, but not definite enough. The suction valves on water at 200 to 210 degrees should be under a head of at least three feet, if it is ever necessary to run the pump at a speed of 70 feet per minute, or more.

H. E. FISHER.

Boston, Mass.

On page 633 of the September number C. R. McGahey tells of trouble with a hot-water pump. I had the same trouble and upon the advice of a brother engineer cured it by putting a tee in the suction pipe close to the pump. Straight up out of this I ran a pipe 10 feet long, leaving the top open. This will let the vapor and water separate and will also act as a sort of reservoir to keep the pump well supplied with solid water.

R. MANLY ORR.

Brantford, Ont.

C. R. McGahey's plan of piping an open heater to a hot-water pump, on page 633 of the September number, would not work at all if he were feeding with a belt-driven or any other direct-driven pump. The pump barrel must be allowed to fill and this could not be the case if throttling were resorted to. By placing an open stand-pipe close to the pump all water hammer will disappear, and this will also prevent water hammer with the steam-pump feeding.

R. A. G.

Dauphin, Man.

A Screw-pump Model

The photographs show a model for a screw pump of my own design, concerning which I should be pleased to receive opinions and suggestions from POWER readers. The pump consists of a screw 2½ feet long and 12 inches in diameter, three threads to the foot, with a groove in the screw to hold regular pump packing. The depth of the groove is equal to two-thirds of the thickness of the packing, therefore the packing cannot turn over. The cylinder is cast in two parts, as shown, to afford easy access. The suction and discharge ends are separate parts fitted with stuffing-boxes.

There are no valves. Any kind of power can be used to operate the pump, connection being made on the side at the suction end.

I think that a pump of this character will more nearly approach the piston or plunger type, in point of duty rendered, than will a centrifugal pump. The water leaves the cylinder naturally and therefore is not likely to churn much. The packing fits the cylinder closely, preventing backward flow, if the screw is running at sufficient speed. Then, too, if operated by means of an electric motor the speed will not have to be reduced to accommodate the speed of the pump.

I have not tried the pump, because none has been built.

CHARLES O'NEIL.

Smithfield, Penn.

Etiquette Among the Construction Force

The letter on "Etiquette in the Engine Room," which appeared on page 479 of the July number, has suggested to me that some observations on "Etiquette among the Construction Force" might be of interest and value to those who are engaged in the construction of power plants, and perhaps give those on the operating end some idea of the little difficulties met with in making the construction organization work harmoniously.

The boaster may be met with in every field of endeavor, perhaps more so in engineering, in which abundant opportunity offers for bragging of the size of plants, rapidity of construction and economies obtained. A failing which often manifests itself among the construction force is that of one man boasting of his past achievements, especially to the resident engineer, the object perhaps being to pave the way for striking for an increase in salary.

It sometimes happens that the resident engineer is a specialist in one line, having a general knowledge of power-plant work, sufficient to coördinate all the men under him, themselves specialists, into one harmonious whole. Nothing can be more distasteful to the head of the force than to have an assistant try to show his own superiority over his chief in his knowledge of certain details.

In consulting his chief regarding a certain line of work, the tactless assistant is apt to display some amusement over the lack of familiarity of the chief with certain details, forgetting that he himself is responsible for the details, while his chief is director of the whole project.

If the shoe be on the other foot and the chief be somewhat inclined to think he "knows it all," an incorrect statement on his part would better not be directly contradicted. The better way is to use diplomacy, and with "It seems to me that", etc., the assistant should be able to put the matter in its correct light.

I have known but one boaster who could back up his claims, and his boasting seemed due, not so much to a desire to impress others with his own ability, but rather to a lack of self-control, a sort of wearing his engineering heart on his sleeve.

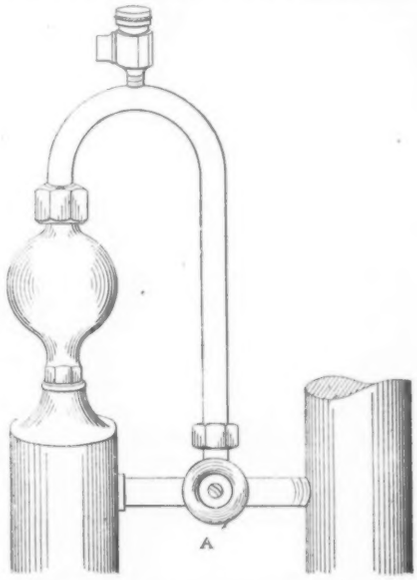
In conclusion, I would admonish any member of a construction force, who is inclined to criticize the engineering ability of his chief, of the epitaph suggested by Andrew Carnegie for himself: "Here lies a man who knew enough to gather around him men smarter than himself."

B. WISE.

Pine Bluff, Ark.

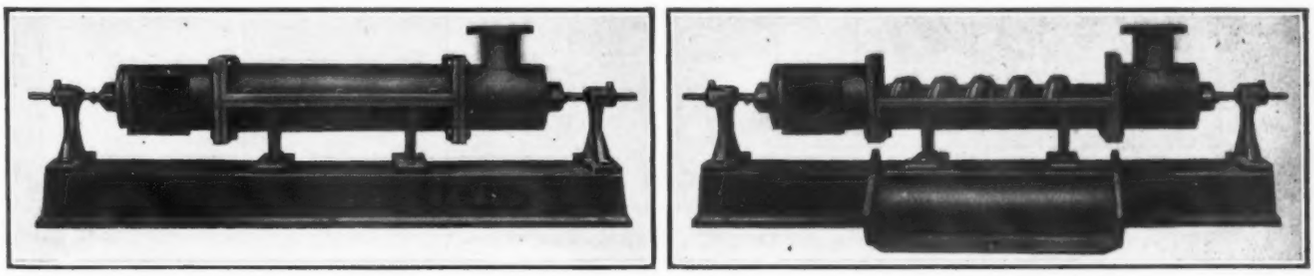
An Air-bound Lubricator

Mr. Sheridan's lubricator arrangement shown on page 633 of the September number brought to mind an experience of several years ago which caused me several days study before I hit upon a remedy. The single-connection lubricator which was at the bottom of the trouble was furnished with a duplex pump. It worked all right for a few hours after it was installed, then it refused to feed. After blowing it out and refilling, it worked O. K. for a few hours more, and then quit again.



HOW AIR-BOUND LUBRICATOR WAS "CURED"

Two or three days afterward happening to place my hand on the top of the



EXTERIOR AND INTERIOR VIEWS OF A SCREW-PUMP MODEL

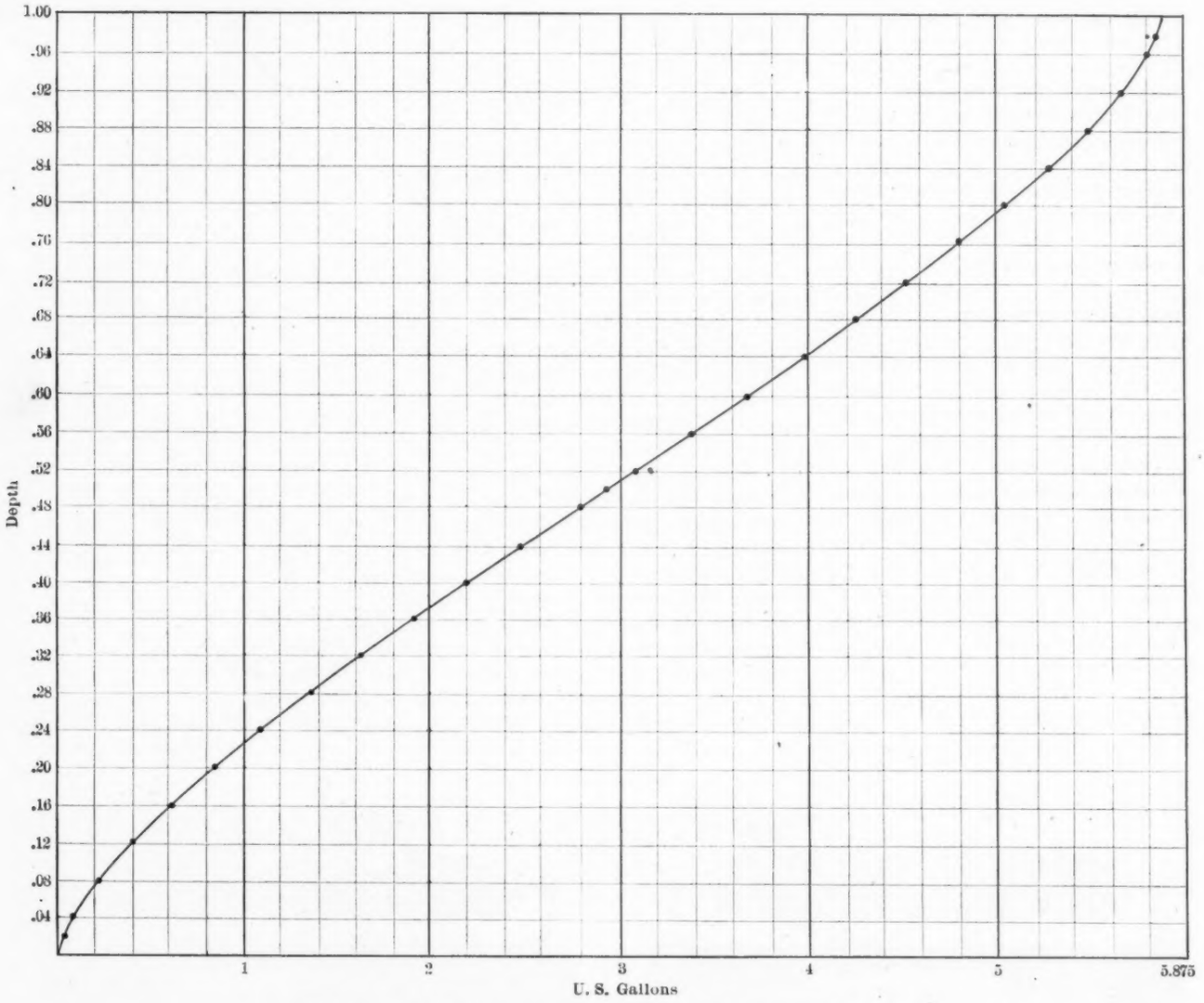
goose-neck, I found that the pipe was comparatively cool. Then it occurred to me that it was air-bound. I closed the valve *A*, removed the goose-neck and brazed in a radiator air valve, as shown. There has been no trouble with it since.

G. R. WILLIAMS.

Findlay, O.

How to Graduate a Measuring Stick for a Tank

An inquirer wants to know of an easy method to mark a measuring stick for a cylindrical tank, with flat heads, which lies on its side. The object may be most readily accomplished, with sufficient accuracy for most purposes, by the aid of a curve that indicates the contents of a tank of unit size at any depth. Such a curve is shown in the accompanying diagram. The tank referred to is one foot in diameter and one foot long. The hight of any point of the curve above the base line denotes, according to the vertical scale, the depth of the liquid; and the horizontal distance from the vertical line at the left, as indicated by the scale at the bottom, represents the contents at that depth in gallons of 231 cubic inches each.



CURVE TO INDICATE CONTENTS OF A TANK OF UNIT SIZE AT ANY DEPTH

Since the areas of similar segments of circles are proportional to the squares of their diameters, the quantity of liquid in a cylindrical tank for each foot of length can be obtained by multiplying the quantity contained in the unit tank at a corresponding depth by the square of the diameter of the first tank. Again multiplying by its length, the entire contents will be obtained. For example, find the quantity of oil contained in a horizontal tank 10 feet long and 5 feet in diameter, when the liquid is 1 foot deep.

The depth is 1/5 or 0.20 of the diameter. Referring to the diameter, the quantity corresponding to a depth of 0.20 is 0.84 gallon. The quantity of oil in the tank is, therefore, $0.84 \times 5 \times 5 \times 10$, or 210 gallons.

In order to graduate a gage-stick so as to show the depths of certain quantities, the operations just employed are reversed. In this case find the corresponding quantities in the unit tank, and then, by the aid of the curve in the diagram, the corresponding depth is found. For example, to show how to proceed to mark a stick for the tank just mentioned, each division on the stick to denote an interval of 100 gallons: The quantity in the unit tank corresponding to 100 gallons is equal to this quantity divided by the product of the square of the diameter and the length of the tank considered. Then, $100 \div (5 \times 5 \times 10) = 0.40$ gallon. From the curve find the depth corresponding to 0.40 gallon to be approximately 0.12 of the diameter. The mark on the stick indicating 100 gallons, will, therefore, be 0.12×60 inches $= 7.2$ inches from the end.

Since 0.40 gallon on the diagram corresponds to 100 gallons in the tank, 0.80 gallon on the diagram corresponds to 200 gallons in the tank. It is, therefore, evident that the location of additional marks on the stick will be determined by finding on the diagram the depth for 0.80 gal-

lon, 1.20 gallons, and so on. Again illustrating the use of the curve, the depth for 0.80 gallon is, according to the diagram, 0.194 of the diameter, and the corresponding mark on the stick for 200 gallons is $0.194 \times 60 = 11.6$ inches from the end. The calculation for the remaining divisions can now be continued in the same simple way.

Gage-rods for vats and tanks not having the same size at the top as at the bottom can be graduated in a similar manner, if a depth-area curve is first constructed, but a curve must be drawn for each of the vessels unless their corresponding dimensions are in proportion.

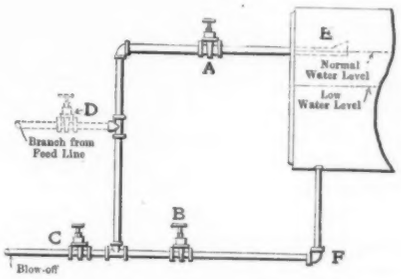
M. D. G.

Scranton, Penn.

Feeding through the Blow-off

Recently several contributors have taken a stand in favor of feeding through the blow-off. In view of the fact that I have fed two of my boilers through the blow-offs for more than seven years, without damage, inconvenience or expense, I think I ought to take my stand with the others. When these boilers are in operation and the fires are maintaining a good ebullition and circulation, I have no misgiving whatever about pumping in water as cold as it runs; but the one thing which I *do* guard against is pumping in cold water when the boilers are not hot and the fire is out, or very low. Should this ever be done the cold water will simply lie along the bottom of the shell, and there will be stresses worth almost half empty. Since then I have been very careful.

Besides these two boilers, there is a separate boiler which is provided with circulation blow-off and skimmer arranged as in the accompanying diagram. With *A* and *B* open and *C* shut, as during operation, if the water level ever got below the skimmer *E*, the circulation would stop and scale and mud would gather and choke up the blow-off at *F*. This was remedied by putting in a branch



MR. ORR'S SUGGESTION FOR FEEDING THROUGH BLOW-OFF

from the feed-line, as shown by the dotted line. Then, by closing *A* and *C* and opening *B* and *D* the pipe was easily cleared. This also comes in very handy at washing-out times, when the same thing is very likely to occur.

R. MANLY ORR.

Brantford, Ont.

Regarding Mr. Hobart's description of "A 100-horse-power Steam Plant" in the July number, and Messrs. Cederblom's and Chaddick's comments thereon in the September number (page 632), I cannot agree with them about feeding the boiler through the blow-off. I believe it is the worst place Mr. Hobart could find. It is sure to scale the rear tube-sheet and cause leaking of tubes, unless the feed-water carries no scale-forming matter, which is a rare thing indeed.

The best boilers in this region are mostly sent from the shop already fitted with a top feed of some kind, and they give splendid satisfaction. Also, it is much easier to keep the tubes in good order than by rear-end feeding, whether through the head or blow-off. If the blow-off pipe is provided with a circulating connection, no trouble will result from the blow-off pipe going out; or if the drop-pipe from the bottom of the shell is long enough to bring the horizontal pipe below the fire, or below the ashes in the combustion chamber, little if any trouble may be looked for. Feeding through the blow-off will in many cases cause this pipe to become much contracted by scale formation, and instances have been known where this pipe became at last entirely closed, or so nearly so that enough water could not be forced through it to feed the boiler properly, thereby causing a shut-down.

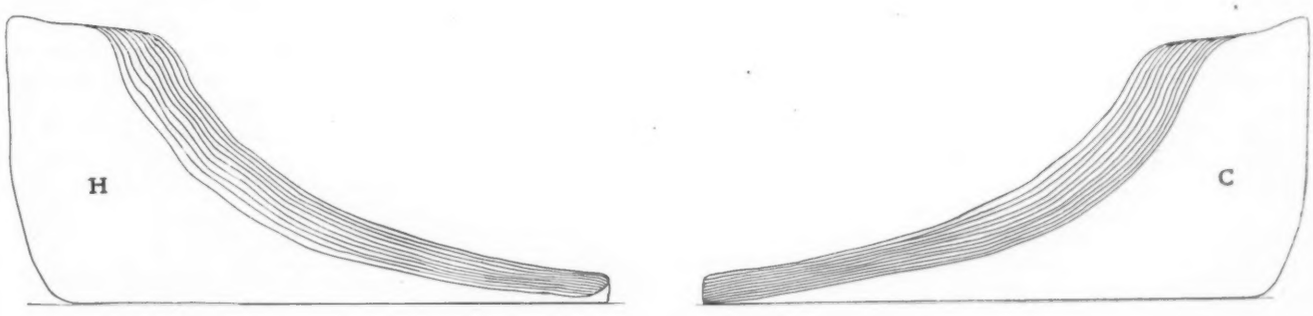
R. A. G.

Dauphin, Man.

Two More Diagrams from a 14x36 Corliss Engine

In the July number, on page 475, J. Burns comments upon the two indicator diagrams from a 14x36 Corliss engine, which were shown on page 395 of the June number, and which, as stated in my letter at the time, were submitted for the "boys to guess at." As Mr. Burns' heart seems to be filled with sweet sympathy, and it is easy to forgive under such incentive, I submit the accompanying diagrams from the same engine for his especial benefit.

It is a single-eccentric engine, as Mr. Burns suggested, but there was nothing



TWO MORE DIAGRAMS FROM A 14X36 CORLISS RUNNING AT 92 REVOLUTIONS PER MINUTE

talking about. I found this out by experience when I started in to learn the business. A back hand-hole leaked, and as soon as I shut down that night I drew the fire and pumped in cold water (the boiler was fed through the blow-off), in order to take the steam down. I pumped the gage glass full (it had been nearly empty), then went behind and opened the blow-off to lower the water again. To my surprise the water came out cold, just as it had gone in, and it continued to come out cold until the gage glass was al-

the matter with the eccentric. The curious caper of the steam in the crank end of the cylinder was due to a twisted stem in the inlet valve and a very badly set exhaust valve. A new keyseat in the steam valve-stem settled the trouble, as can be seen from the new diagrams. These diagrams show an increasing load, covering 25 revolutions. The machine drives a Westinghouse generator for lighting purposes.

A. P. ALDRICH.

Greenwood, S. C.

Lubrication of Modern High-pressure Engines

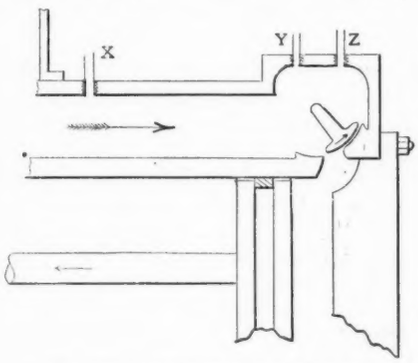
For some time I had been under the impression that the subject of lubrication of modern high-pressure engines is not given much thought, so recently I took a look around to see what I could find out about it. At the first place I visited I found an old friend, a 24x48 Corliss engine; it had just been installed there, having been removed from another plant. I saw that the old hydrostatic lubricator had been discarded for a modern force-feed oil-pump. I asked the engineer how he liked it and he replied that although it did not fully meet requirements, the cylinder-head seemed to be "good and greasy" all the time. He also said he used one quart of oil every nine hours. As I only used one quart in twenty hours on the same engine, with the old lubricator, I tried to figure out why it required more now. I noticed that it was a double-feed pump, with a feed for each end of the cylinder, the oil entering the chest just over the valve, as at *Y* in the accompanying sketch. The arrow shows the direction of the valve movement. There being no current of steam over the back of the valve, whenever oil dropped into the chest the rush of steam would carry the oil down through the port and most of it would strike the cylinder-head. It was a single-eccentric engine, therefore the valve had considerable lap, with the dash-pot down, and this part of the valve was well oiled. Then, when the valve opened, it would oil the back-bearing surface of the valve seat acceptably, too, except with light loads, when the oily portion of the valve would not turn back far enough to properly lubricate the seat, and the valve would become dry. This is one case where, in trying to put the oil just where it was needed the job was a failure.

In another plant, a large mill, the same conditions were met with. The pump feed entered at *Y*, and there was in addition a double-feed lubricator of the hydrostatic type, with its feed entering the chest at *X*. The engine used about three times the quantity of oil with the force-feed pump as with the old lubricator, so the former was given up. When using the old lubricator, the oil was well distributed throughout the steam and the valve and cylinder became well oiled. Also, appreciably less oil leaked around the trap under the receiver.

In another plant there is a tandem-compound engine with an oil-pump on each cylinder; also, a sight-feed lubricator connected just above the throttle. The old hydrostatic lubricator was being used when I called, the pumps having been discarded because they took about twice as much oil as the sight-feed lubricator.

All this looks bad for the force-feed lubricator, I know, but it is not the fault of the oil-pumps, but in the way they were connected up. For instance, take the case of a horizontal 72x60 engine that I once saw. It had been in use twenty hours a day for seven years, the piston speed being 750 feet per minute. Previous to the last time the head was taken off, it had been in steady operation for eighteen months, and the only thing that had to be done was to put the head on again and start up. This cylinder is equipped with a four-feed pump, connected as shown at *Z* in the sketch. In this case the oil drops down behind the valves and it must properly lubricate the valve before it can go to the cylinder. In doing this it is broken up and distributed all along the edges of the double-ported valve, the steam sweeps the particles of oil into the cylinder, and no oil whatever is deposited on the cylinder-head.

Another case was that of an elevator pump which was oiled by a force-feed lubricator. It gave good service, except that the pump governor did not work as



LOCATIONS OF FEEDS FOR ENGINE LUBRICATION

freely as it ought. The lubricator discharged its oil in the Y-connection just before the steam entered the chests. The engineer changed the feed so it would enter the steam line just above the governor. The result was that the governor worked perfectly and the pump required about one-third less oil.

In another case a high-speed engine was equipped with a hydrostatic lubricator above the throttle, a force-feed lubricator feeding directly into the steam chest. It was found that the engine would run on less oil if fed above the throttle than with the feed in the chest, so the force-feed lubricator was discontinued. One day, however, the lubricator above the throttle got out of order and the engineer took the lubricator off and run the discharge from the pump into the connection above the throttle, with the result that the pump is still doing the lubricating on that particular engine.

Referring to the sketch again, there does not seem to be much difference between the positions of *Y* and *Z*, yet it simply shows that if the feed is placed directly over the valve, which is sometimes done to get proper lubrication of the valve, one must take into account the direction of rotation of the valve. While as a general thing, for low-pressure work it is necessary to put the oil right on the valve to get good results, I do not believe that the same holds good as regards high pressure. For my part I prefer the location *X* as the point of feed for Corliss engines. For small engines and pumps I believe the proper place to feed the oil is at the steam line.

In the case of two feeds to each end of the cylinder, most people object to feeding back as far as *X*, because unless the holes are drilled closely together it will require more drilling to get through the chest. In case the valve opens in a direction opposite to that shown in the sketch, it will be a comparatively easy matter to lubricate it, as the oil must pass over it to get to the cylinder. In that case, the locations *Y* and *Z* would have to change places for correct low-pressure work.

In conclusion, I believe the force-feed lubricator has come to stay, but it is sometimes expected to do impossible things and its reputation suffers in consequence. I am very well pleased with them myself, yet I would not throw hydrostatic lubricators in the junk-pile and replace them with pumps, especially in the small sizes, unless the old lubricators are beyond all help.

Every engine requires to have its own particular conditions studied out before the pumps can be properly connected up, as Smith's engine may be an altogether different proposition from Jones'. One may have the valves working in one direction and the other may have an opposite movement. In one cylinder atomizing of the oil may be depended upon to do the work, another may be a low-pressure cylinder and it may be necessary to put the oil directly on the valves. It is also a well-known fact that eighteen inches of steam line, more or less, between the lubricator and the engine has a lot to do with the proper disintegration of the oil.

EDWARD H. LANE.

Kansas City, Mo.

Gaskets for Hand-hole Plates

We used to experience a great deal of trouble with leaks around hand-hole plates on the mud-drums. The surfaces around the plate and hole would become rough and uneven, due, no doubt, to continued leaking. After spending considerable money for fiber gaskets, we decided to make a mold with which to manufacture corrugated-lead gaskets. First, a wood pattern was made from a piece of white pine, which was planed and sawed hexagonal, and from this pattern two 1½-inch cast-iron plates were made, Fig. 1. One side of each plate was faced and a groove turned in each, so that when placed

together the cross-section looked like the sketch, Fig. 2.

A mixture of two parts lead, one part tin and one part babbitt was melted until the metal flowed freely in the grooves. The plates were held together by clamps and when the metal became cool the clamps were removed, and the plates

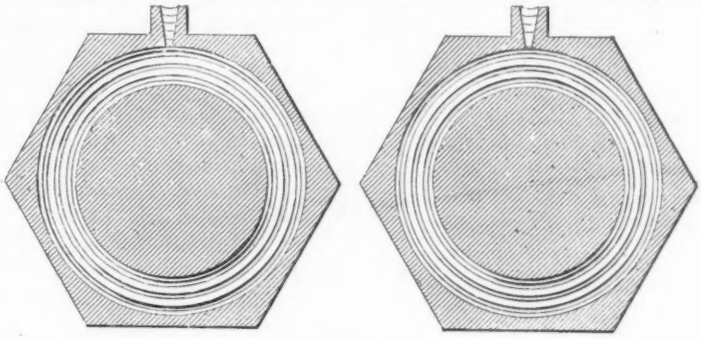


FIG. 1

FIG. 2

fell apart. The gasket was then trimmed, and when cold it was easily pressed into an elliptical form to fit the hand-hole plate. After the molding plates were made there was practically no expense, as one man could make three or four dozen in an hour.

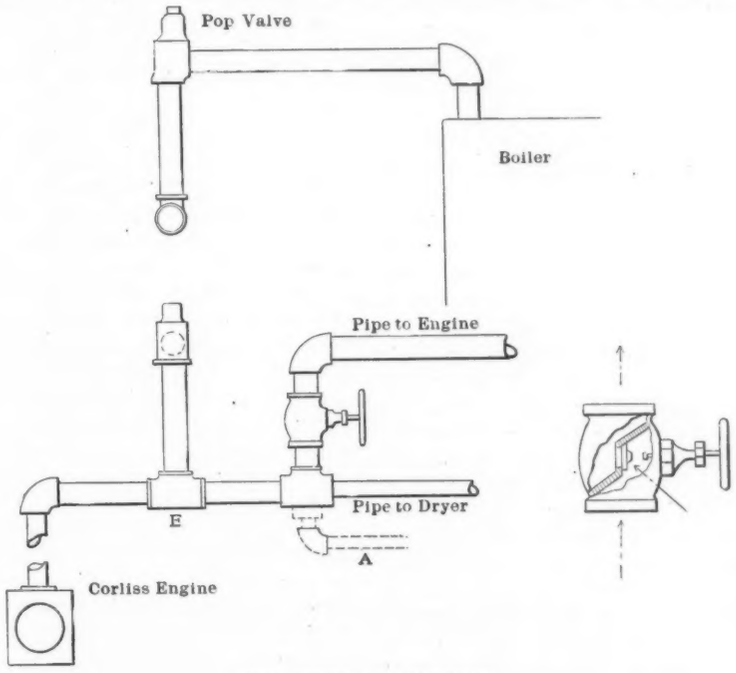
J. BURNS.

Columbus, O.

Another Poor Piping Arrangement

The illustration herewith shows piping that was well put together, but the arrangement was poor. This was in connection with a high-pressure vertical boiler, with a pipe leading from the top of the boiler horizontally to the pop-valve, then dropping to the main line. The large pipe runs to a Corliss engine with a branch leading upward to an auxiliary engine, with a throttle valve in the branch. It will be seen by reference to the valve section that the steam forced the disk against the seat instead of against the screw, with the result that the disk came off and shut down part of a large plant, the shut-down costing as much as would an entire system of piping. This valve, which should have been put on in the reverse position, cut off a 100-foot main which contained another valve at the engine.

The Corliss engine has been wrecked several times by water, on account of this method of piping. The small pipe leading to the drier forced water through the engine, as the pipe leading to the auxiliary would not carry off any of the water. Had the pipe to the drier been put in as shown at *A*, it would have been much better. A better way than this, however, would have been to locate a cross or a small outlet at *E*. The drier pipe could have led out at this point, and the pipe would act as a drain, perform its work just as well and keep the water from the engine.



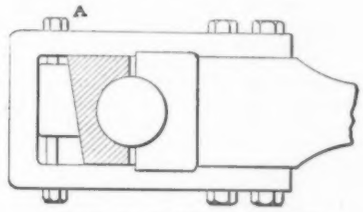
POOR PIPING ARRANGEMENT

C. R. McGAHEY.

Cedartown, Ga.

A Peculiar Knock in an Engine

The most peculiar engine "knock" I have knowledge of was experienced with a high-speed tandem-compound engine which one day suddenly started to pound very hard. The knock seemed to come from the crank-case, but was not continuous; that is, it kept up for a dozen revolutions or so and then would stop for a few turns as suddenly as it started. It



CAUSE OF KNOCK IN ENGINE

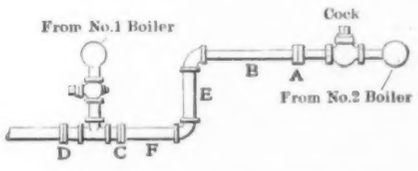
kept us guessing until we had a chance to shut down, when it was found that the bolt-head shown at *A* in the sketch here with had broken off, and this allowed the wedge to drop, causing the pounding. Through centrifugal force, however, the wedge was thrown up against the brass once in a while, when the load was off this side of the pin, where it managed to stay for a few revolutions.

R. CEDERBLOM.

Chicago, Ill.

Location of Blow-off Pipes

The accompanying illustration shows a good way of arranging the main blow-off pipe on two horizontal return-tubular boilers, where the blow-off connections from the two boilers lead into one main pipe. Should it become necessary to repair or replace a defective blow-off cock on No. 2 boiler, the flange *A* is disconnected and the pipe *B* raised away from one part of the flange. If the cock on No. 1 boiler should leak, the flanges *C*



LOCATION OF MAIN BLOW-OFF PIPE

and *D* are disconnected, and by unscrewing the two nipples *E* and *F*, the cock can be removed without disconnecting any of the pipes on the other boiler. If the threads on all of the pipes are covered with graphite mixed with oil, and also the gaskets and bolts on the flanges, there will be no trouble in getting them apart.

H. JAHNKE.

Milwaukee, Wis.

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Retire the Lap-riveted Boiler

The Board of Boiler Rules of Massachusetts has taken a commendable step looking toward the disqualification of the lap-riveted boiler. In the first set of rules which it promulgates, it allows a factor of safety of 5 for lap-riveted boilers, the longitudinal joints of which are directly exposed to the products of combustion for the first ten years of their lives; 5.5 for boilers over ten and not over fifteen years old; 5.75 for boilers over fifteen and not over twenty years old; and 6 for boilers over twenty years old; while boilers with the butt-and-strap joint are rated with a factor of safety of 4.5 irrespective of age, their construction being such as to allow the inspector to observe deterioration as it occurs and to qualify the allowed pressure accordingly. By thus placing the lap-riveted boiler at a decided disadvantage its further manufacture will be even more discouraged than it has been by the recent numerous destructive failures of boilers of this type, and by the growing sentiment against it. The use of this type of boiler should be made so onerous that its manufacture would be superseded in favor of a type that will not be a public danger—more than that, a constant and dependable cause of loss of life and property.

In the meantime, what is to be done with the thousands of boilers of this type which are running with cracks which extend through the rivet joints between the sheet, beyond the ken of any inspector, and undiscoverable except by the destruction of the joint, the cracks growing deeper with every change of shape of the boiler under the varying conditions of pressure and temperature? The fact that thousands of dollars are invested in such boilers should not be allowed to weigh against the fact that hundreds of lives will be sacrificed and more thousands of dollars' worth of property destroyed, before they are off the earth.

It is a notable fact that among all the recent failures of lap-seam boilers not one was made of iron, and there are still a large number of iron boilers of that type in use, notwithstanding the wide adoption of steel. Thomas Hawley, ex-chief boiler inspector of Massachusetts, advances the idea that on account of the laminated structure of the iron it is difficult for a surface crack to work its way through, the laminations acting to check the progress of the crack as does the hole which is often bored to stop a crack under other circumstances. At all events, the iron boiler has so far proven immune from this kind of failure, while the owner of a lap-riveted boiler does not know what day it may let go. The most disastrous recent explosions have been of this type of boiler, subjected to the best inspection procurable and under the best of care. No more should be made, and it will be a glad day for the steam engineer and the insurance companies when the last of them becomes junk.

The Lantern in the Association

The blackboard might properly be given a prominent place in the insignia of those organizations of which the National Association of Stationary Engineers is the type. Meeting for mutual improvement through the discussion of engineering subjects, as soon as the routine business of the association has been disposed of all eyes turn to the blackboard, and many a man has been helped out of a difficulty and many another started upon the study habit by the "chalk talks" given by his fellow members upon the association blackboard.

But while the blackboard should always have a prominent place in the association meetings, there are many things which can be much better done by the lantern, and many of the associations are providing themselves with these to the great benefit of the educational work. Many a member who can talk most interestingly with a boiler front for a blackboard and a group of his fellow workmen as listeners fails to develop under the more formal conditions of the meeting room. Some of them with excellent ideas have the greatest difficulty in making a drawing to illustrate them, and even when a man is a good draftsman much valuable time is lost in putting an elaborate sketch upon the board.

Photography has been reduced to such simplicity that there is usually at the command of an association, if not among its members, somebody who can make slides from real objects, from photographs, from drawings, from articles in books and papers, and in this way matters of interest can be readily placed before the association for description and discussion. Many slides, too, can be procured by writing to the manufacturers of steam engines, turbines, boilers and accessory apparatus, and it would be an effective way for such manufacturers to make engineers better acquainted with the essential features of their wares, the proper methods of setting, adjusting and caring for them, to furnish a number of slides with a printed description and directions for the use of associations equipped to use them. Finally, many of the lecturers available to talk to associations illustrate their lectures by means of slides, and an association with its own lantern is in a position to avail itself of such lectures at short notice and at no expense.

How Should Globe Valves be Placed?

The fact that this question is constantly recurring is because there is no direct answer to it. Many disputants settle it offhand by declaring that the pressure should come under the disk, so that the stem can be packed when the valve is closed. But a disk is not nearly so favorably situated to resist pressure and leakage when it is supported only by the thrust of the stem in the center, as it is with the pressure on top and the edge of the disk supported by the seat. The pressure underneath tends to curl the disk up like a saucer, to unseat it, and the load comes on the stem and threads. It is obviously harder to keep it tight than when the pressure tends to seat it, especially upon large valves. If the stem fails or becomes detached from the disk, the valve cannot be opened in one case nor closed in the other. It seems to us that the consequences of failure should be considered for each particular case.

Test of a Westinghouse-Parsons Turbine

On page 772 will be found the report of a test of a Westinghouse-Parsons turbine at the Waterside station No. 2 of the New York Edison Company. Aside from the statement of the steam consumption attained, 14.8 pounds per kilowatt-hour, 10.65 pounds per brake and 9.8 pounds per indicated horse-power-hour, the report is interesting as describing two new methods for taking care of details which simplify the test and conduce to accuracy in the results.

The first of these was the method used for obviating a correction for gland leakage. A continuous gland-water circuit was established entirely between the turbine and the weighing apparatus, so that all the water leaking into the turbine through the glands was taken from the hot-well overflow before it was weighed and was thus automatically deducted.

The second was the method used for measuring the condenser leakage. The circulating water was salt, and the salinity of the condensed steam, which without leakage should be pure distilled water, was thus a measure of the leakage. This salinity was determined by the nitrate of silver test, and as this could be done at any time and as often as desired it determined not only the total amount and average rate of leakage, but the rate at any interval of the test.

The conditions of the test were not exactly those of the guarantee. The above figures are those corrected from the actual performance. The average steam consumption was 15.15 pounds per kilowatt-hour, with 177.5 pounds pressure, 95.74 degrees superheat and 27.31 inches vacuum. The available energy from a pound of steam worked between these limits is 263,994 foot-pounds. The performance therefore represents 66.36 per cent. of the available energy. Under the guaranteed conditions of 175 pounds initial, 100 degrees superheat and 28 inches vacuum, there are available from each pound of steam 276,703 foot-pounds of energy, so that the corrected result of 14.8 pounds per kilowatt-hour represents 64.8 per cent. of the available.

Boiler Inspection in Indiana

If the reports which come to us from Indiana are true, the State will do well to pass a real boiler-inspection law. According to our information the factory laws require boilers of certain classes to be internally inspected twice a year by an engineer of at least ten years' experience in operating power boilers at over seventy pounds pressure, by a boiler maker of at least five years' experience, or by an inspector of some boiler-insurance company doing business in the State; but no provision is made for an official inspector.

It is said that an engineer holding a government inspector's position is taking advantage of the situation to go about demanding to inspect stationary boilers and charging ten dollars for looking them over and tapping them a bit while they are under steam. Whether or not this is a fact, it is well to call attention to the fact that a thorough internal inspection is required and that one engineer of the prescribed experience is as much an "official inspector" for that purpose as another.

Some Gas-engine Possibilities

When the internal-combustion engine reaches the cost level and state of commonplace dependability of the steam engine, the fields that it will occupy, not to say monopolize, will be wide in scope and enormous in extent. Why, for example, should there be any further use for the steam locomotive, with its coal consumption of from fifteen pounds per horse-power-hour up—almost always up? Again, why should not interurban railways and heavy-duty urban railways use internal-combustion engines instead of central stations, eliminating the expensive system of feeders and distributing mains and possibly the electrical equipment? If a gas or crude-oil locomotive will not give sufficiently rapid acceleration, however, the remedy would seem to be a modification of the Heilmann plan—electric transmission between the prime mover and the car wheels.

As to power stations and steamships in which fuel economy is a big factor, it is obvious that the producer-gas engine will supersede the steam engine there—when it attains the stage of development stipulated above. In isolated plants of the factory class, there does not seem to be much prospect of anything like monopoly by the gas engine, but its use in that field will, of course, increase tremendously. In irrigation work there is an enormous field which has been barely touched so far, although there are many oil engines in use in that class of work. In fact, in every place where fuel is high-priced or its cost is a large proportion of the total operating expense, the internal-combustion engine is destined ultimately to reign supreme. Is much intelligent effort being made in this country to hasten the day?

Wireless Power Transmission

At intervals during the past month or two rumors have been circulated and vague items have appeared in the daily papers to the effect that somebody in France has discovered a marvelous method of transmitting electrical energy through space—without the use of wires. No details have been supplied, and not even a hint has been dropped as to the scientific principle on which this "discovery" is based. The most that any of these reports has contained is the statement that a miniature car has been propelled a distance of two hundred yards by means of electrical energy transmitted without connecting wires.

Of course, no one can afford to say that the scientific knowledge of electricity is complete, and that wireless power transmission can never be achieved. But it is justifiable to say that so far as electrical science has progressed, such transmission on a commercial scale is not practical; some absolutely unknown principle will have to be discovered in order to make it so.

Electrical energy is transmitted through space, of course, when a "wireless" telegram is sent, but the quantity of energy actually transferred is absurdly small in comparison with the expenditure of energy at the transmitting station. To send a message one hundred miles by wire under ordinary commercial conditions requires energy expenditure at the rate of about one-hundredth of a horse-power; to accomplish the same result by wireless telegraphy requires about two horse-power, or about two hundred times the rate of energy expenditure that the wire system needs. Of course, wireless transmission is susceptible of further improvement, but it is quite obvious that the commercial transference of energy through space at high rates cannot be accomplished by means of high frequency electrical waves, and that is the only long-distance method known to science.

The Sturtevant Steam Turbine

When the practicability of the steam turbine was becoming apparent, its particular adaptability to the driving of the blowers and small electric generators of its manufacture was impressed upon the B. F. Sturtevant Company, and experiments were begun in the direction of the development of a turbine suited to these particular requirements. The experimental work was conducted by William E. Snow of the engineering staff and the turbine is built under his patents.

As will be seen from a little study of Figs. 1 and 2, this is still another example of the Riedler-Stumpf type. The steam enters at the side of the bucket through nozzles, shown separately in Fig. 3 and located at *AAAA* in Fig. 1, and maintains a whirling motion in the closed spaces formed by the revolving bucket and those of the stationary guide-plate, being repeatedly returned to the guide-buckets, at a reduced velocity, to react upon the wheel and have more of its energy absorbed. When it has acted in four of these stationary buckets it commences to find an escape into the interior of the case through the open-ended guide-plates at *BBBB*. The term "involute" has been applied to this type of turbine on account of the direction of flow of the steam. The Sturtevant single-stage involute turbines are made for capacities ranging from 10 to 200 horse-power and are furnished in three sizes as regards outside dimensions, the various powers and speeds required being produced by the arrangement of the nozzles and buckets. The turbine in this form consists of seven principal parts—the bucket-wheel, the shaft, reversing guide-rings, the casing, the bearing, the base and the governor. On account of the repeated return of the steam to the

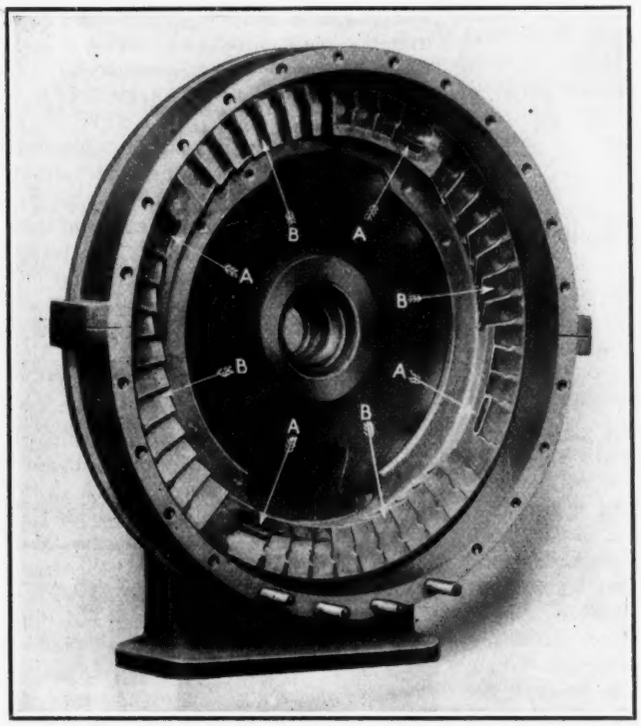


FIG. 1. REVERSE GUIDE-RING, AND CASING, SHOWING NOZZLES

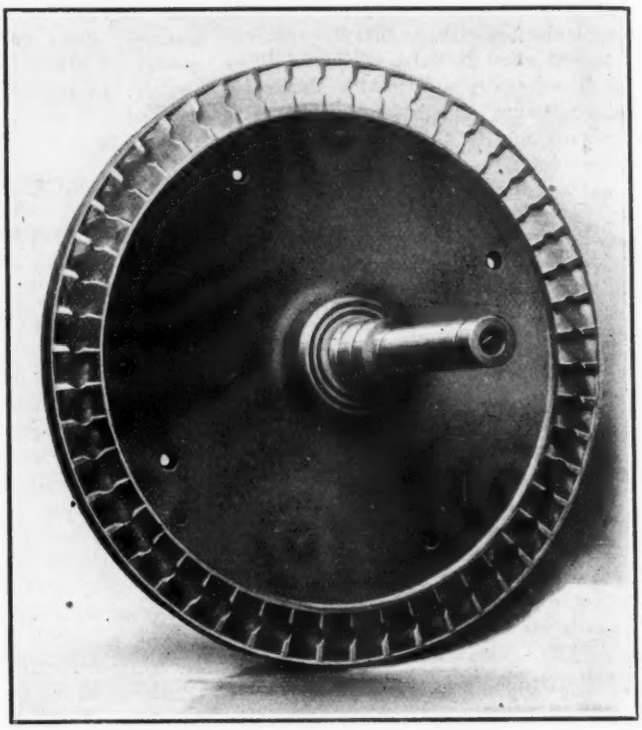


FIG. 2. FINISHED BUCKET-WHEEL, RADIAL-FLOW TYPE

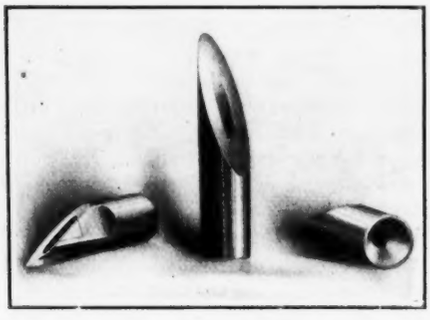


FIG. 3. THE NOZZLES

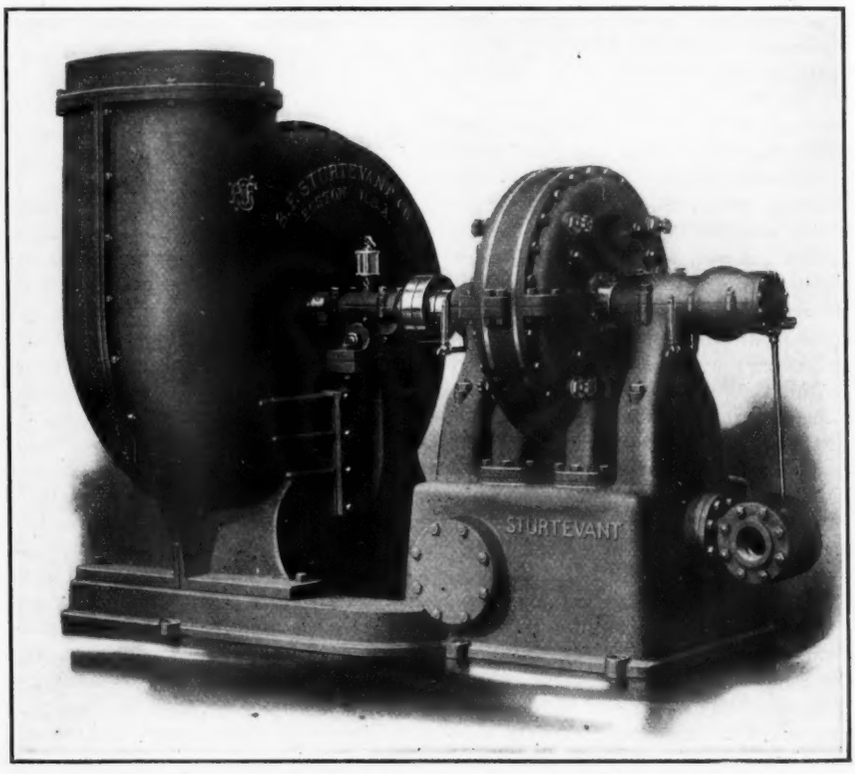


FIG. 4. A STURTEVANT 75-HORSE-POWER TURBINE GAS-BLOWER SET

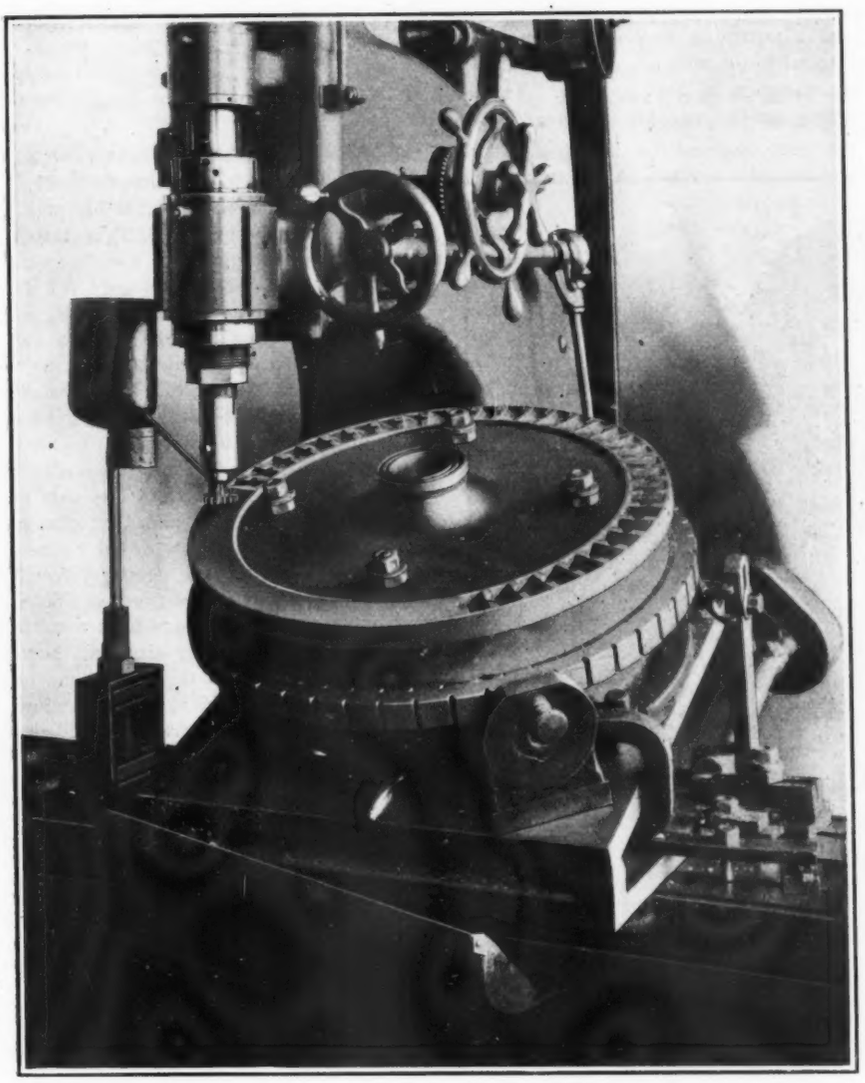


FIG. 5. BUCKET-CUTTING MACHINE

wheel and its multiple action thereon the speed of the turbine can be comparatively low, allowing rotative speeds of from 1600 to 3000 revolutions per minute, which permits their direct-connection to blowers and high-speed machines and avoids the use of gears and other speed-reducing mechanism. At the above speed the steam leaves the wheel with little residual velocity and with its energy largely absorbed. Fig. 4 shows a 75-horse-power turbine direct-connected to a gas blower.

It is not quite apparent from the engraving that the rotor shown in Fig. 2 is a double-bucket wheel, i.e., that its reverse side is the same as the side shown, and that this double-bucketed disk runs between two of the guide-plates so that there is no tendency to end-thrust. There is a clearance of 1/16 of an inch all around the revolving bucket-wheel so that there is little liability of contact from change of shape under unequal heating or lack of alinement, but should contact occur it would be much less disastrous with a wheel cut from a solid disk in this way than it would be with a series of exposed inserted blades. This will be appreciated more fully after inspection of Fig. 5, which shows the operation of milling the bucket and makes it apparent that the possible damage from contact would be only such as would result from the contact of a solid disk running at the given velocity.

In sizes above 200 horse-power the turbine is made in stages, the required number of expansions being divided between from two to four of the bucket-wheels upon the same shaft. Instead of milling buckets into the side of the disk,

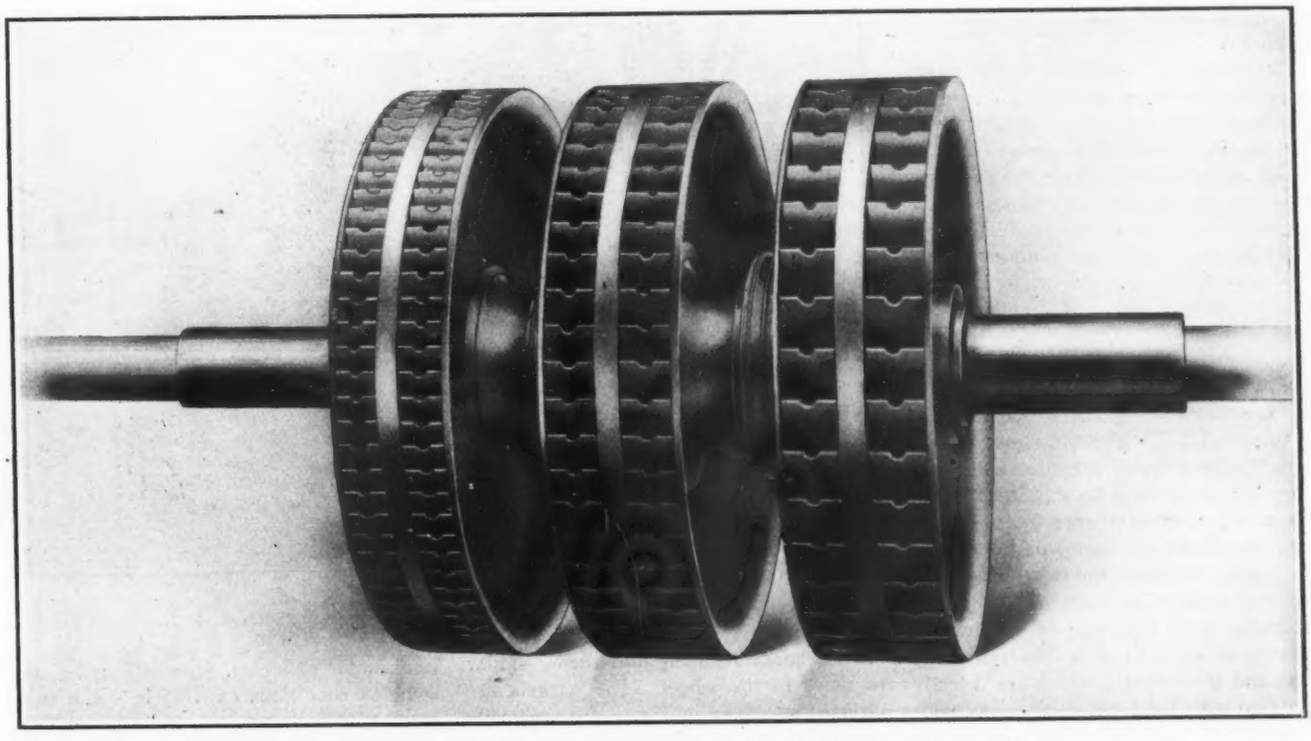


FIG. 6. BUCKET-WHEELS FOR STURTEVANT 3-STAGE 250-HORSE-POWER TURBINE

as shown in Figs. 2 and 5, they may be milled at the edge, as in Fig. 6, in which case the jet acts tangentially. Fig. 6 is a reproduction of a photograph of a rotor of a three-stage 250-horse-power turbine,

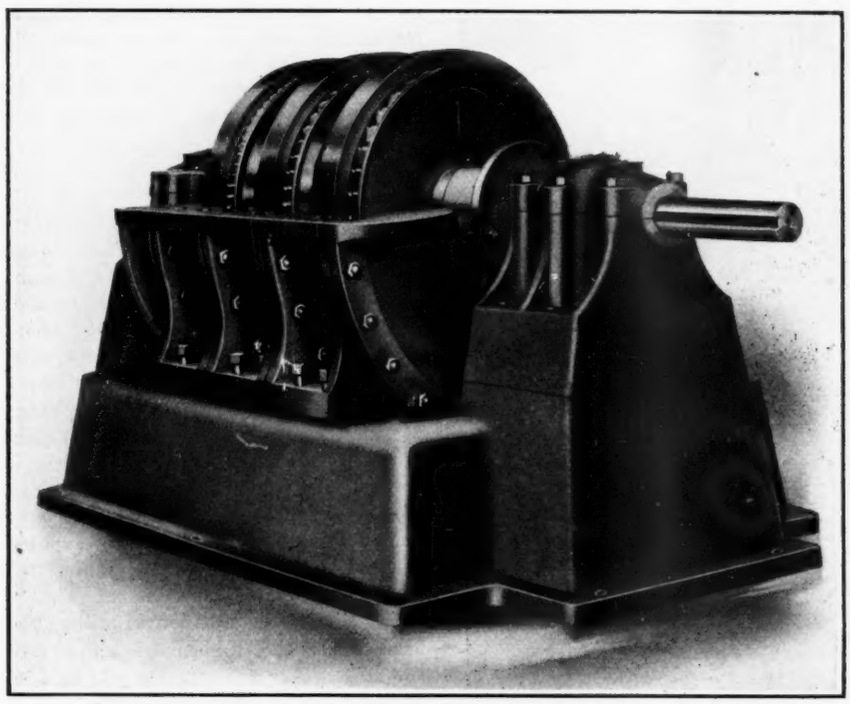


FIG. 7. STURTEVANT 250-HORSE-POWER THREE-STAGE STEAM TURBINE PARTLY ASSEMBLED

and it will be seen that the areas of the nozzles and buckets increase successively upon the three wheels to allow for the greater volume of the expanded steam. Either the side or tangential form of bucket may be used with either the single- or multiple-stage type. Figs. 7 and 8 show this multi-stage turbine partly and fully assembled.

The speed is controlled by a direct-connected throttling governor, having but four parts and one spring, located at the end of the outboard bearings and inclosed in a dust-proof case. The single-stage type is used for all ordinary work; the multi-stage being reserved for cases where an unusually large amount of power is required in a small space, or where high pressure and a large range of expansion are to be taken care of. As there is a pressure of only 14 pounds per square inch upon the main bearing, the only surfaces in contact, the wear should be inappreciable. The bearings are of the self-alining type, ring-oiled with solid linings of phosphor bronze. Steam-tightness at the shaft is secured by the use of short labyrinths or water packing, with no contact between the stationary and revolving parts. The deep base which the extremely small diameter of the turbine necessitates is utilized for carrying the steam and the exhaust, which are directly connected with the base, doing away with all unsightly overhead piping. The steam passages in the base are also arranged to form a separator, insuring dry steam so essential to the long life of the nozzle and the efficiency of the machine. The reversing guide-rings are of forged steel, having buckets milled into them, similar to those in the wheel. The buckets are inserted as shown in Fig. 1 and are easily removable for inspection or renewal.

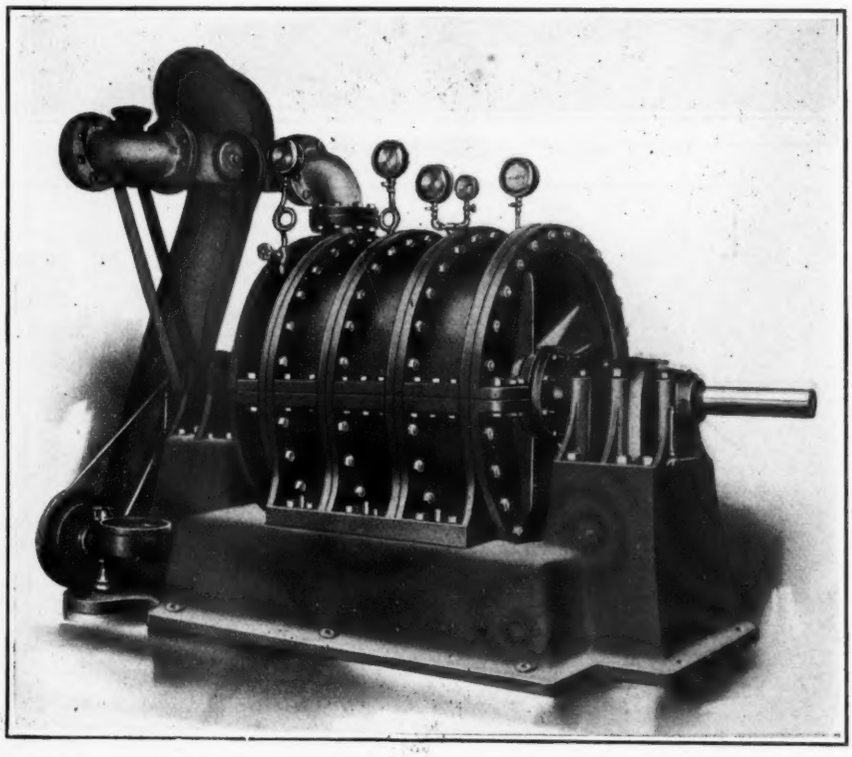


FIG. 8. STURTEVANT 250-HORSE-POWER THREE-STAGE STEAM TURBINE FULLY ASSEMBLED

The Thomas Steam Calorimeter

By Carl C. Thomas

Figs. 1 and 2 show the exterior and the general interior arrangement of a steam calorimeter with which the quality of any steam passing through the instrument can be determined in a very simple manner. It is especially designed for determining the quality of steam at different points along steam turbines, and it can be used with steam of any degree of wetness and of any temperature and pressure above that in the condenser. The sampling tube leading to the calorimeter, and shown in Figs. 7 and 8, may be extended into any steam passage from one part of the turbine to another and the average quality may thus be investigated by taking successive samples from different depths. From this information combined with the results of ordinary tests a curve may be drawn on a heat diagram, showing the distribution of the work done by the steam in the turbine, and indicating the efficiency of the various sets of blades or buckets. Such a curve may also be used to indicate the degree of initial superheat that should be contained in the entering steam in order that the steam at any set of blades may be in a given desired condition as to heat contents.

The difficulty of obtaining a representative sample of steam, especially under the complex conditions existing in steam turbines, is fully recognized, and the sampling tube shown in Figs. 7 and 8 has been de-

signed to assist in obtaining definite results. With this tube, it is at least possible to obtain samples from given definitely known depths or positions in a steam passage.

The development of the instrument resulted from experiments in passing steam from an electrically heated calorimeter

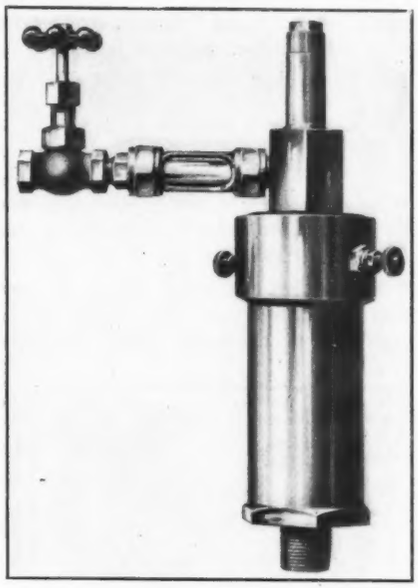


FIG. 1. EXTERIOR VIEW OF THOMAS CALORIMETER

through a transparent glass tube. If the electrical energy supplied to the steam in passing through the calorimeter was insufficient to dry the steam, water could be seen in the interior of the glass tube; also no rise of temperature was shown on a thermometer placed in the tube. By adding sufficient electrical energy to the steam, the interior of the tube cleared up because of the disappearance of the water, and the temperature began to rise at the same instant that the steam gave this evidence of being completely dry. It was therefore possible to measure directly the amount of heat required to dry the sample of steam, and from the known heat of vaporization of dry steam, and the known weight of steam passing through the calorimeter, the quality could be readily found. The method of ascertaining the weight of steam passing per unit of time is described in the following paragraph.

In operation, the calorimeter is attached to the sampling tube or to the source of steam directly, by means of the screw-thread *A*, Figs. 2 and 3. Steam is thus admitted to the instrument, from which it passes to the condenser or to the atmosphere, through a pipe from the discharge valve, placed at *C*. Having adjusted the discharge valve so it is passing a suitable quantity of steam, enough energy is turned in to heat the steam to dryness. The condition of dryness is indicated by an immediate rise of temperature as shown by the thermometer, if more than the requisite amount of electrical energy is supplied. For convenience let the watts necessary to dry the steam be called E_1. After noting this number of watts, the steam is further heated by additional watts, E_2, till a temperature T degrees above saturation is obtained; say 20, 30, 100, or some other convenient number of degrees of superheat. This operation is for the purpose of ascertaining the weight of dry steam per hour, W_1, which was passing when the steam was just dry. The weight W_2 passed through the valve after superheating will be less than the dry steam passed through, by some percentage represented by a constant, C, because of the increase in volume accompanying superheating. This has been determined by test with the in-

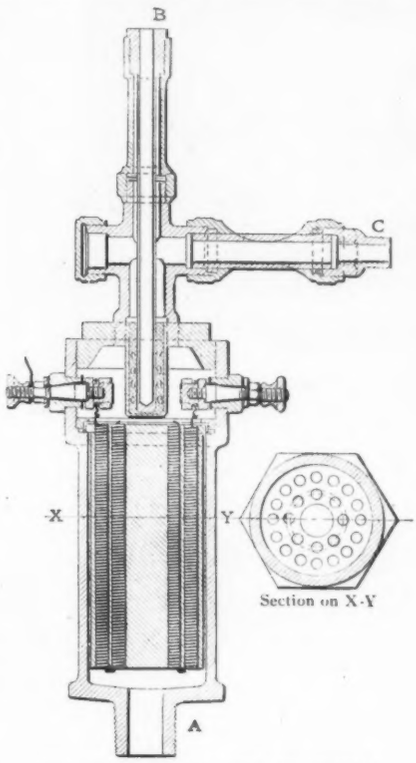


FIG. 2. SECTIONAL VIEW OF THOMAS CALORIMETER

struments. Also, the watts, S, necessary to superheat a pound of steam to T degrees, at different pressures, have been determined. The latter, S, may be used instead of the specific heat of steam and has the advantage of allowing automatically for radiation losses. The quality of the steam may be obtained either by the use of curves supplied with the calorimeter, or by the use of the mean specific heat of steam for varying pressures. The use of the curves, however, eliminates entirely any possible errors due to uncertainty as to the value of the specific heat.

Let W_1 = weight of dry steam passing per hour; then E_1 watts evaporate the moisture in W_1 pounds per hour and this energy is equivalent to $\frac{3.412\,E_1}{W_1}$ thermal units per pound of steam. Let this amount of heat be represented by H_x. Let W_2 = weight of superheated steam passing per hour = $C\,W_1$; then E_2 watts raise the temperature of $C\,W_1$ pounds of steam through T degrees, or $E_2 = C\,W_1\,S$ watts, where S represents the watts required to superheat one pound of steam per hour through T degrees, at the pressure in the calorimeter. Then.

$$W_1 = \frac{E_2}{C\,S},$$

and this value may be substituted in the equation,

$$H_x = \frac{3.412\,E_1}{W_1},$$

thus,

$$H_x = \frac{3.412\,E_1 \times C\,S}{E_2}.$$

Since C and S are constants for any given pressure and degree of superheat, $3.412\,C\,S$ may be written as a constant K, and values of this constant are given for varying pressures and degrees of super-

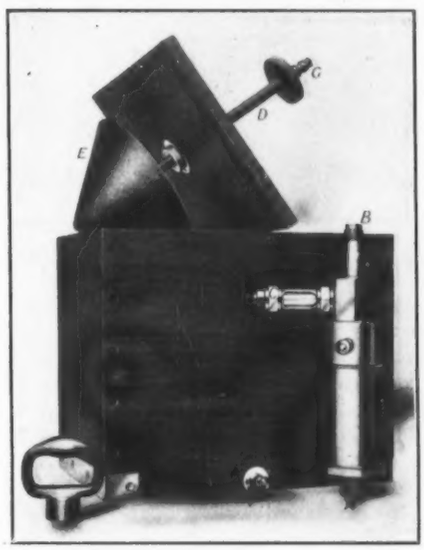


FIG. 3

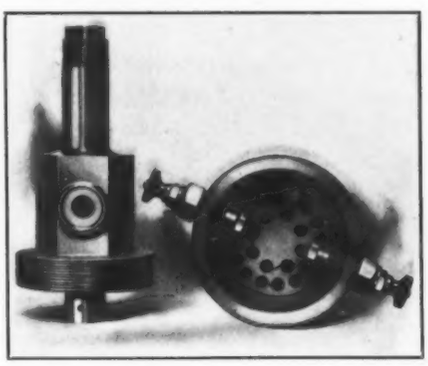


FIG. 4

heat, by a set of curves plotted from experimentally obtained data. See Fig. 9.

The equation then becomes

$$H_x = \frac{K\,E_1}{E_2}.$$

If H_v represents the heat of vaporization of dry steam (from steam tables) at the pressure indicated by the original

temperature in the calorimeter, the quality of the steam passsing through the calorimeter is

$$x = \frac{H_v - H_r}{H_v}.$$

It is to be noted that the constant K is independent of the weight of steam flowing through the calorimeter during superheating, although consideration of this weight has been included in the explanation just given. The same result may be found without the use of either C or S. The independence of K upon these quantities may be shown as follows:

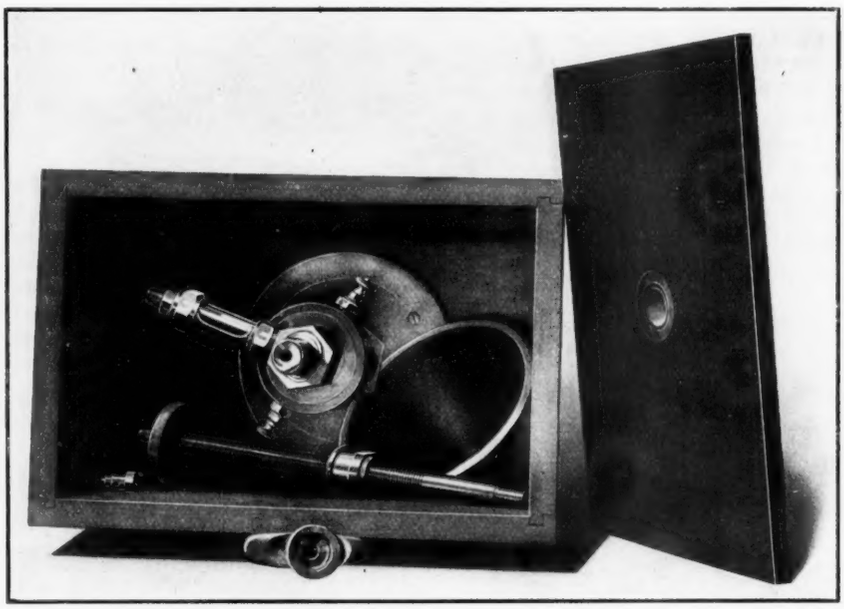


FIG. 5. CALORIMETER PARTS AND BOX

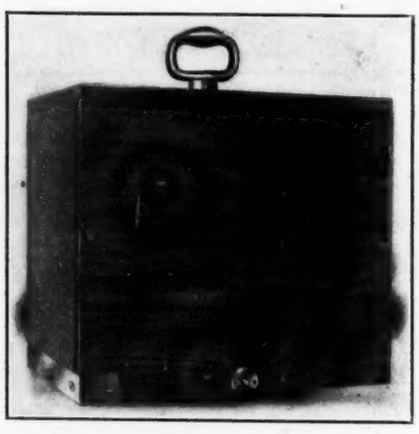


FIG. 6

$$C = \frac{W_2}{W_1} \text{ and } S = \frac{E_2}{W_2}.$$

$$K = 3.412 \quad SC$$

$$= 3.412 \times \frac{E_2}{W_2} \times \frac{W_2}{W_1} = \frac{3.412\ E_2}{W_1}.$$

It is therefore possible to find the expression for K without using C or S. Thus, if the steam flowing through the calorimeter is first dried, by the introduction of E_1 watts, then superheated through T degrees by a further introduction of E_2 watts, it follows that for each pound of the original weight W_1 of dry steam, it has taken $\frac{E_2}{W_1}$ watts to superheat the *steam coming from* W_1 pounds of dry steam through the given temperature range T. Hence, for the pressure and temperature in question, $\frac{E_2}{W_1}$ is a constant (which may be called k) and $W_1 = \frac{E_2}{k}$. Substituting this value of W_1 in the equation $H_s = \frac{3.412\ E_1}{W_1}$, thus,

$$H_s = \frac{3.412\ E_1\ k}{E_2}.$$

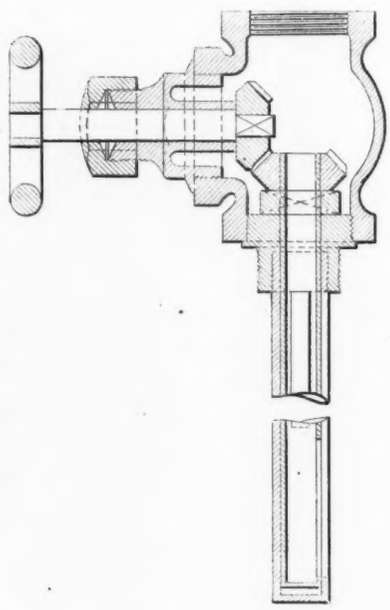


FIG. 7. SECTIONAL VIEW OF SAMPLING TUBE

Let $3.412k$ be called K, then

$$H_s = \frac{K\ E_1}{E_2},$$

as before found.*

Summing up the operations involved in determining the quality of steam, they are as follows:

1. The calorimeter is attached to the source of steam and a flow of steam takes place through the electrical heating coils, and out through the discharge valve at C, Fig. 2. Electrical connections are made with an ordinary direct-current circuit at perhaps 125 volts, capable of carrying about 10 amperes. The calorimeter is put in series with the water rheostat, and means are provided for measuring the input of electrical energy.

2. Sufficient electrical energy is supplied not only to dry the steam, but to superheat it to some convenient tem-

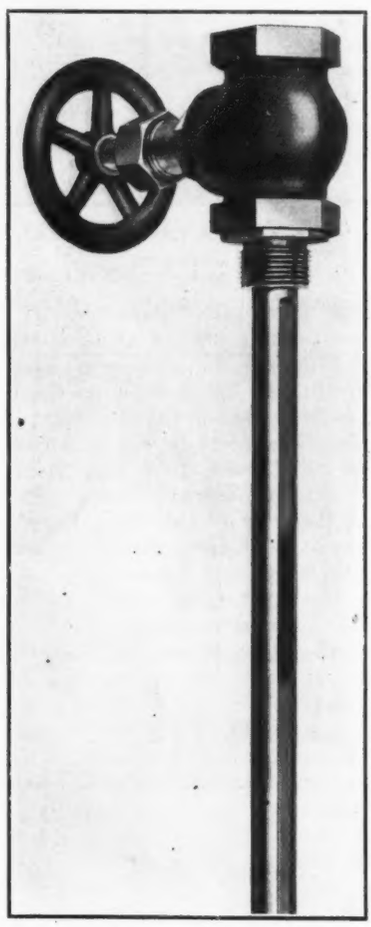


FIG. 8. EXTERIOR OF SAMPLING TUBE

*The constant 3.412 is the number of B.t.u. equivalent to 1 watt-hour. Its development may be shown as follows: 1 horse-power-hour is equivalent to 33,000 × 60 or 1,980,000 foot-pounds.

1 B.t.u. is equivalent to 778 foot-pounds.

Therefore 1 horse-power-hour is equivalent to

$$\frac{1,980,000}{778} = 2545 \text{ B t.u.}$$

But 1 horse-power-hour is also equivalent to 746 watts.

Therefore 1 watt-hour is equivalent to

$$\frac{2545}{746} = 3.412 \text{ B.t.u.}$$

perature. The watts introduced are called E_T. Now turn out energy until superheating no longer takes place and the steam is, therefore, just dry. The energy now being introduced is only that necessary to dry the steam, and is called E_1. The condition of dryness is indicated as before described. Then $E_T - E_1 = E_2$ watts required to superheat the steam through T degrees.

3. From the curves select the value of the coefficient K corresponding to the degree to which the steam was superheated, add to the original temperature in the calorimeter, and find the heat H_x, which has been added to each pound of steam in order to dry it, from the equation $H_x = \frac{K E_1}{E_2}$.

2. Lag with a piece of 4-inch pipe covering extending from the bottom of the calorimeter to the top of the thermometer tube and cover the top of the calorimeter with loose, dry asbestos. Cut two holes in the lagging for electrical connections and one for the steam-outlet pipe.

3. Put water in the rheostat box till it is about half full and add one or two small cupfuls of common salt to the water. Attach the adjustable cone to the rheostat cover by means of the brass adjusting screw and connect the rheostat and an ammeter in series with calorimeter. Direct current at 110 to 125 volts is ordinarily used with the calorimeter; higher voltages may be used if desired, up to about 220 volts. The resistance of the calorimeter is about 10 ohms when cold. Connect a voltmeter across the terminals of the calorimeter. A wattmeter of one thousand or fifteen hundred watts capacity may be used instead of the ammeter and voltmeter, if desired. Before taking readings, steam should be caused to pass through the calorimeter for such a length of time as to insure that all parts have been heated up to steady working conditions. Cause steam to pass through the calorimeter before electrical energy is introduced, to avoid damaging the coils.

4. The exhaust valve from the calorimeter may be allowed to discharge to the atmosphere, or, preferably, be connected by a ⅜-inch pipe to the condenser. The outlet from the calorimeter is threaded for a ⅜-inch pipe connection. For steam pressures below that of the atmosphere the condenser connection is required. The glass exhaust nozzle may or may not be used between the calorimeter outlet and the discharge valve. It is of value to the observer in studying the condition of the steam. The exhaust valve may be adjusted so it is passing such an amount of steam that the available electrical energy will dry and superheat it to the required temperature.** At high pressures the discharge valve requires very little opening. At lower pressures, more, and at pressures below the atmosphere it may be left wide open. Fit a ⅜-inch globe valve at the discharge end of the glass nozzle. An incandescent electric light held beyond the glass outlet tube assists in observing the condition of the steam on leaving the calorimeter.

5. Insert a thermometer in the cup at

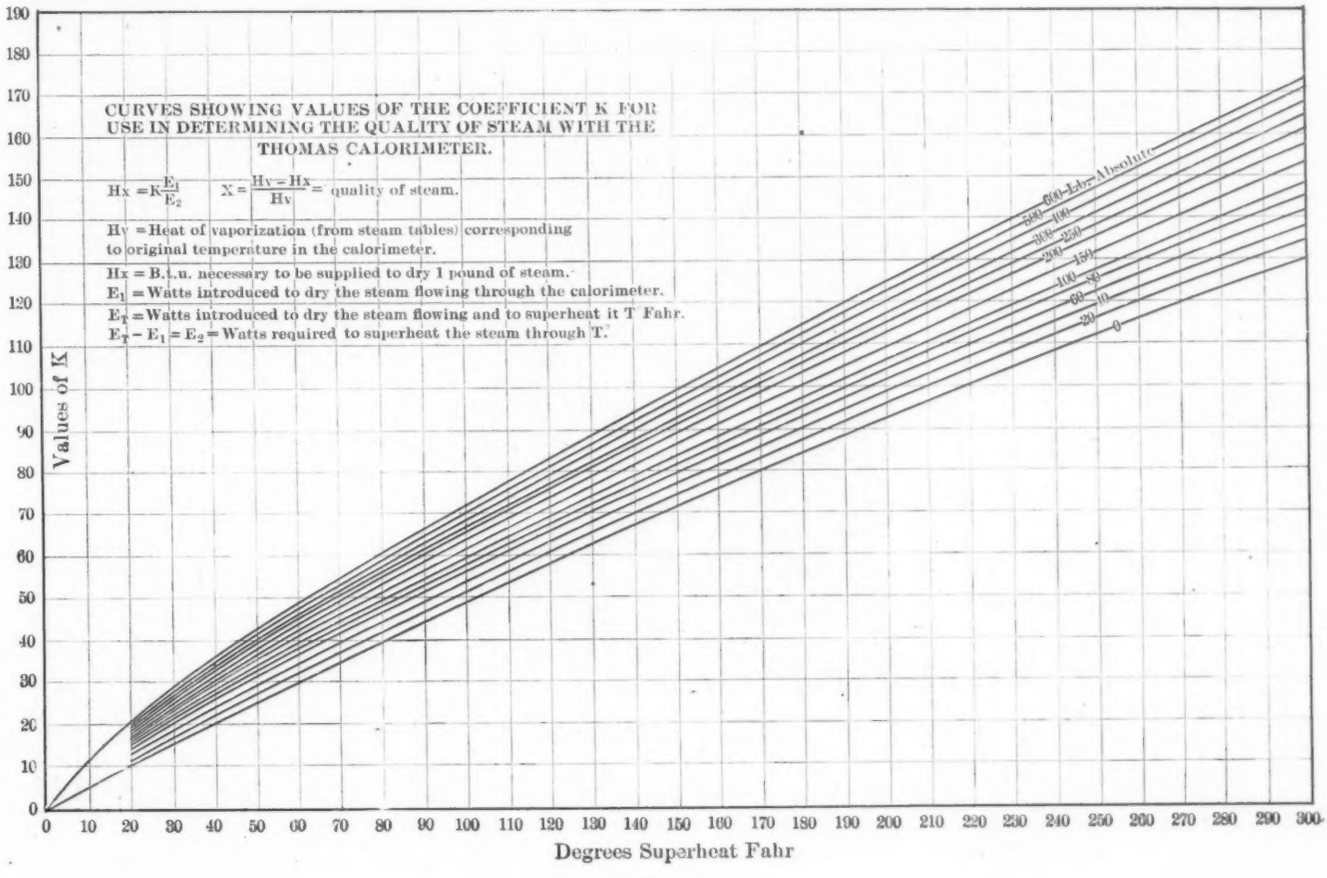

CURVES SHOWING VALUES OF THE COEFFICIENT K FOR USE IN DETERMINING THE QUALITY OF STEAM WITH THE THOMAS CALORIMETER.
Hx = K E1/E2 X = (Hv − Hx)/Hv = quality of steam.
Hv = Heat of vaporization (from steam tables) corresponding to original temperature in the calorimeter.
Hx = B.t.u. necessary to be supplied to dry 1 pound of steam.
E1 = Watts introduced to dry the steam flowing through the calorimeter.
ET = Watts introduced to dry the steam flowing and to superheat it T Fahr.
ET − E1 = E2 = Watts required to superheat the steam through T.
Values of K
Degrees Superheat Fahr
600-Lbs.-Absolute
500-100
300-250
200-150
100-50
60-30
20-10
0

FIG. 9

4. Find the quality of steam from the second set of curves, Fig. 10, representing the equation $x = \frac{H_s - H_r}{H_e}$. The quality may of course be found directly from the equation if desired.

Directions for Operating the Calorimeter

1. Attach the calorimeter in a vertical position to the source of steam of which the quality is to be determined. If a sampling tube is to be used, screw this into the steam space where desired and attach the calorimeter to the sampling tube by means of the screw-thread A.

**The question may be asked, Why not call the the watts required to dry and superheat the steam $E_1 + E_2$, instead of E_T? It will be seen upon reflection that when drying and superheating are taking place together E_1, as previously defined, is not being introduced to dry the steam, because the steam passing through the orifice or valve at the outlet from the calorimeter is less during superheating than during drying of the steam, and therefore the heat necessary to dry the steam passing through the calorimeter is less than E_1. As soon as E_2 has been turned out and the steam is just dry, E_1 is again being introduced, but E_1 and E_2, as defined, are not simultaneously introduced.

the top of the calorimeter. It is better to use mercury than oil in the thermometer cup.

EXAMPLE 1

Let wet steam be passing through the calorimeter, at a temperature of 366 degrees Fahrenheit, as shown by the thermometer in the tube B. This corresponds to a pressure of 165 pounds per square inch absolute. Let 650 watts ($= E_T$) be introduced and let the resulting temperature be 460 degrees. The steam has then been not only dried, but superheated through a range of 94 degrees ($= T$). Let the energy be now reduced until the steam is just dry, and let the watts then being introduced be 260 ($= E_1$):

$$E_2 = E_T - E_1 = 650 - 260 = 390.$$

From the curves the value of K corresponding to this pressure and to $T =$ 94 degrees is $K = 59$.

Therefore,

$$H_x = \frac{260}{390} \times 59 = 39.4.$$

Since the heat of vaporization at 165 pounds absolute is 855.3 B.t.u., and it has been necessary to add 39.4 B.t.u. to each pound of wet steam in order to complete the heat of vaporization, the quality

$$x = \frac{H_v - H_x}{H_v} = \frac{855.3 - 39.4}{855.3} = 0.954,$$

or, from the curves of quality, $x = 95.4$ per cent.

EXAMPLE 2

Let the pressure as indicated by the temperature of 153 degrees in the calorimeter be 4 pounds absolute.

Let $E_T = 480$ watts, and the resulting temperature = 240 degrees, corresponding to a range of 87 degrees superheat.

Let E_1 be found to equal 360 watts. Then $E_2 = 480 - 360 = 120$.

From the curves, $K = 43.5$;

$$H_x = \frac{320}{120} \times 43.5 = 116.$$

From the curves of quality

$$x = 87.7 \text{ per cent.}$$

The calorimeter is supplied with a water rheostat box which serves to control the amount of electrical energy introduced, and also for carrying the calorimeter and accessories. The complete outfit is shown in Figs. 1 and 3, together with the cover for showing how the rheostat is operated. When the box is in use as a rheostat, the cover holds a nut in which a screw D works, for raising or lowering the cone E and thus varying the energy passing the rheostat. The lower terminal connection is shown at F on the box, and the upper is at C, in the swivel nut on top of the operating screw. The box is about 13 inches high and the outfit complete weighs about 43 pounds. When the calorimeter is in the box it is attached to the iron plate forming the lower terminal of the rheostat on the bottom of the box, Fig. 5, by means of the screw-thread A, and the top of the calorimeter projects through the top of the box one-half inch. The brass handle is tapped out and screws on the top of the calorimeter, for convenience in carying the outfit.

The glass outlet from the calorimeter is not a necessary part of the instrument, since the condition of dryness is indicated by the rise of the mercury in the thermometer; but it is useful as giving an optical demonstration that the steam has completely dried, and also in affording an excellent means of studying the behavior of wet and of superheated steam.

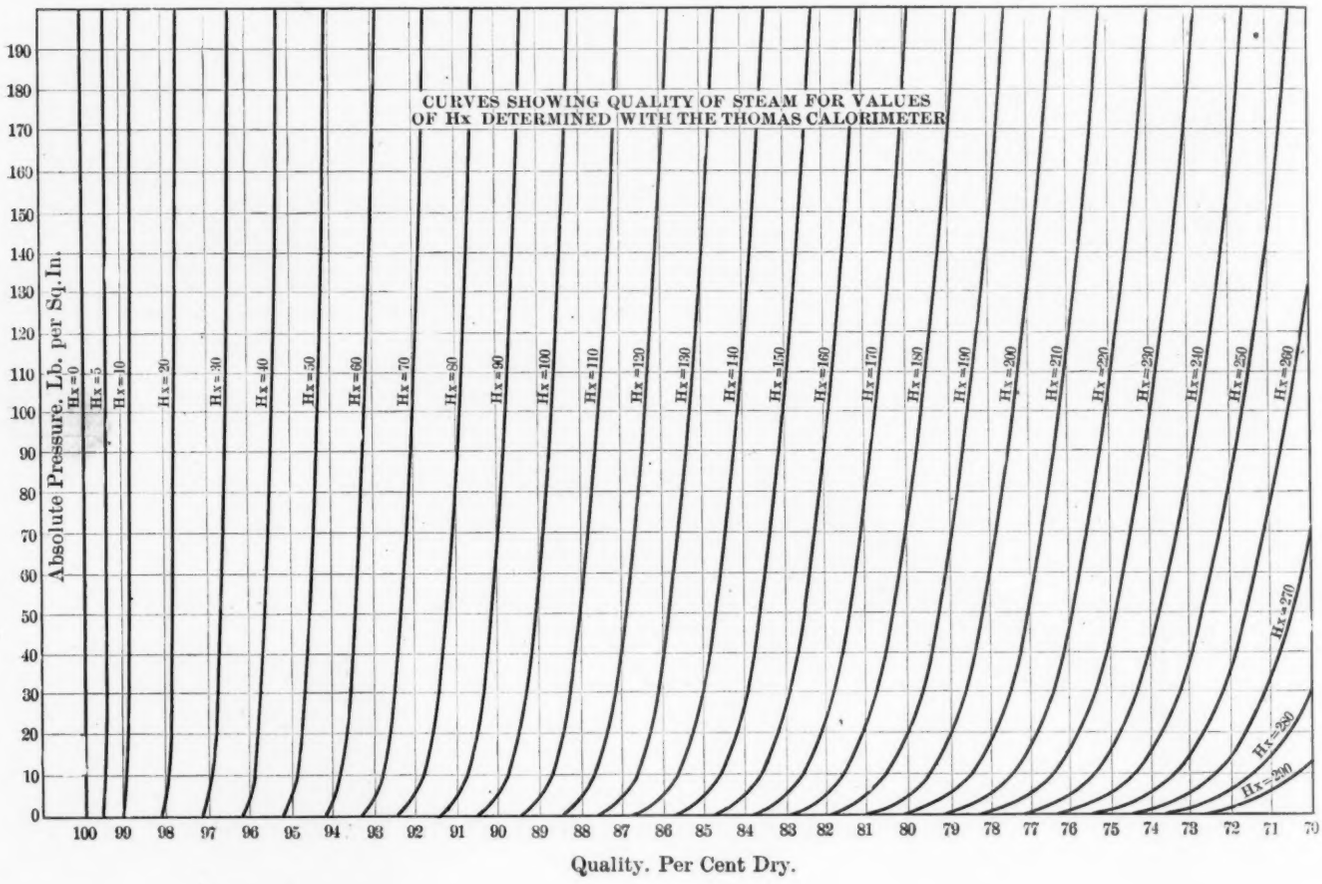


FIG. 10

The sampling tube shown in Figs. 7 and 8 permits of taking consecutive samples of steam from different depths in any steam passage. There are two tubes, of which the outer is stationary and the inner can be rotated by means of the hand-wheel and bevel-gear connections. The outer tube is slotted over its entire length while the inner tube contains short slots which open consecutively into the long slot in the outer tube. It is thus possible to take samples from the different portions of a steam passage without disconnecting the calorimeter, and to know positively from what part the sample is being drawn.

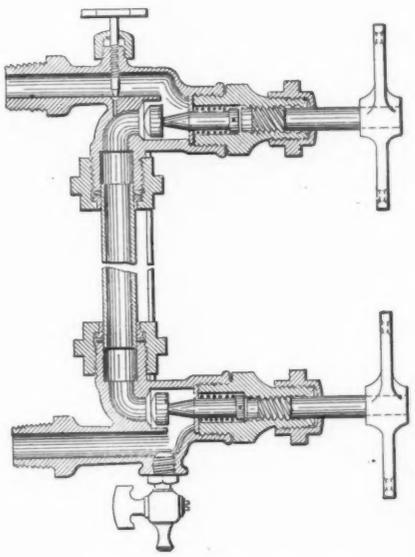
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The "Reliable" Water Gage

The "'Reliable' tempering and automatic water gage" was designed to provide an appliance to instantaneously and



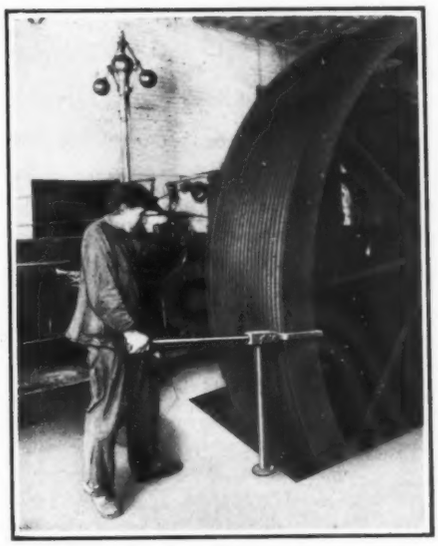
THE "RELIABLE" WATER GAGE

invariably shut off the supply of steam and water from the boiler when a glass tube is broken, and also to provide a means for gradually raising the temperature of a newly inserted glass to that of the steam.

The upper fitting consists of a straight unrestricted chamber leading from the boiler into another chamber containing an automatic plunger having its disk recessed in the back to enable the steam to impinge thereon more effectually when the glass breaks, thus insuring immediate closure. This plunger is held open by means of a spring placed back of the brass bearing washer which further acts as a gasket between the body and the center piece carrying the quick-closing or positive shut-off valve-stem. The steam-tight joint made by this method obviates corrosion of the thread by preventing the steam from touching it, thus permitting ready removal of the center piece and the automatic plungers for the purpose of cleaning.

The pin-valve shown on the top of the upper fitting provides a bypass in the wall between the main chamber and the chamber directly leading to the water glass. This affords a means for gradually heating a newly inserted glass and building up the pressure therein, and for restoring the automatic valve to its normal or open position after the pressure on the glass has reached that of the boiler. The lower fitting differs from the upper only in having a blow-off connection for purpose of cleaning and draining, and no pin-valve is provided, as the one in the upper fitting is sufficient.

One feature of the gage, to which attention is called, is the location of the automatic valve where it can be kept in operative condition by the frequent daily shutting of the positive cut-offs by means of chains attached to the levers. This gage is sold by the Automatic Steam Appliance Company, 605 German National Bank building, Pittsburg, Penn.



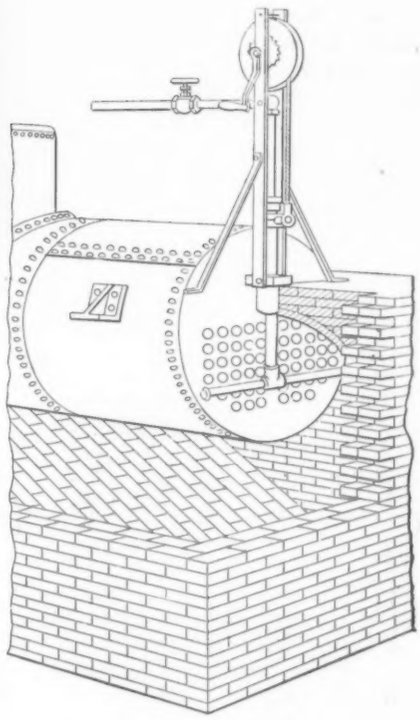
THE CHICAGO ENGINE JACK

"Chicago" Engine Jack

When an engineer wishes to turn his engine off center and has only a plain bar to do it with, he is helpless if he happens to be alone in the engine room; but if he has a jack handy that can be manipulated by one man, without assistance, he is O. K. The "Chicago" jack, recently put on the market by the McMaster-Carr Supply Company, 174 Lake street, Chicago, is an excellent one-man jack, and the illustration shows how handily it can be used. It gives the same grip on the edge of the fly-wheel rim as the old-style bar, and enables the engineer to move the wheel easily, by successive "bites" which may be made frequent enough to keep the wheel moving continuously as long as desired. Such a jack is especially useful in valve setting, when it is necessary to turn the engine from center to center. This jack can be used on belt-driven and rope-driven wheels and on direct-connected engines. All the castings are of crucible steel. The device weighs, complete, about 50 pounds.

The Henry Steam Flue Cleaner

The Henry flue cleaner was patented last spring. It is installed at the rear of the boiler, as shown, and cleans with the draft, the soot being blown forward into the smoke-box extension and up the stack. The nozzle pipe, which covers one row of tubes at a time, is raised or lowered by means of the crank shown at the top, and when not in use is drawn up close under



THE HENRY STEAM FLUE CLEANER

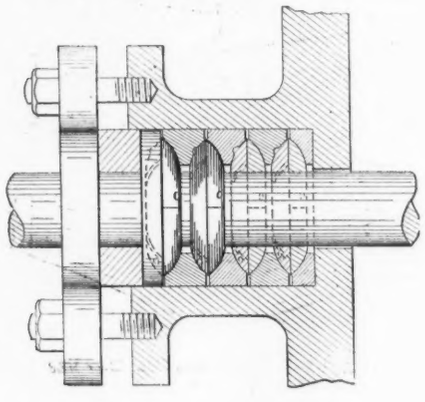
the brickwork, out of the direct path of the hot gases.

The action is direct, close contact being provided with each tube, and opening a valve and turning the crank are all that is required to operate it. It takes about five minutes to clean a set of tubes, and the operation of the boiler is not interfered with while doing it. The appliance may be attached wherever there is at least 4 feet 6 inches of headroom at the rear end of the boiler. It has been put on the market by W. M. Sage, of Minneapolis, Minn.

Rhodes Metallic Packing

This is a rod packing and, as will be seen by the cut, comprises a number of composition metal rings. A small copper wire extends through each ring lengthwise, to act as a spring and insure good contact between rod and ring. These rings are alternated with rubber rings, the sides of which are formed to fit snugly over the oval surfaces of the metal rings, the edges of the rubber rings making tight joints, but not overlapping. At each end is installed a rubber half-ring, with the flat side toward the wall of the stuffing-box. All sectional joints are "staggered" to secure strength and render leakage less likely. When all the rings are in place, the gland is tightened up by hand and the engine started, when the packing is supposed to adjust itself. No changes have to be made in the stuffing-box, nor does the rod have to be removed, as the metal rings can be spread open and clasped around the rod without difficulty. The character of the composition in the rings is varied to suit requirements of service, so that in reality a different packing is furnished for each condition.

This packing is made by the Rhodes

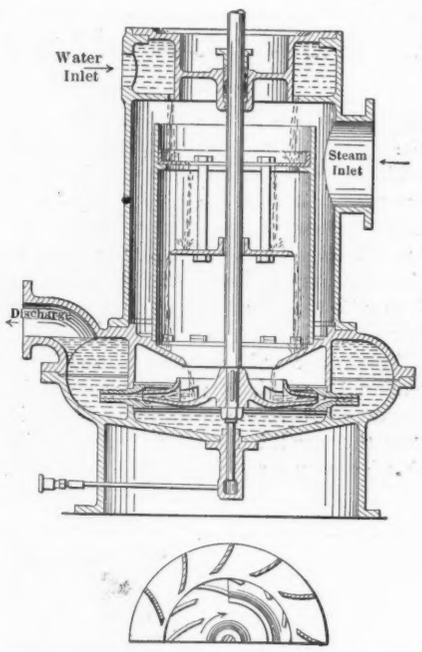


RHODES METALLIC PACKING

Improved Metallic Packing Company, 149 Broadway, New York, for all sizes of rod from ⅛ inch to 2 inches in diameter. The company also makes a metallic packing for bronze pumps.

Jet Condenser and Centrifugal Vacuum Pump

In a recent article upon the condenser, it was pointed out that instead of elevating the condenser so that the water would flow out of it by gravity against the atmospheric pressure, as is done in the barometric type, the condenser may be left upon the floor level and the centrifugal pump used to expel the water and air from it instead of to raise the condensing water to the 34-foot level required. Such an arrangement is shown in the accompanying engraving, which is the reproduction of the drawing of a patent recently issued to Burchard Thoens, of New York City. The water enters the annular space at the top of the condenser and, as shown,



JET CONDENSER AND CENTRIFUGAL VACUUM PUMP

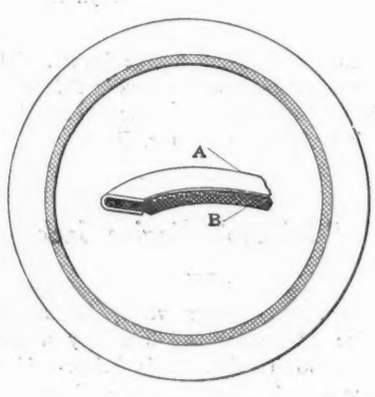


FIG. 1

is showered through the entering steam and discharged into the impeller of the centrifugal pump, which delivers it, together with the air and non-condensable vapor, at the discharge shown at the left.

The Self-sealing Gasket

This gasket is composed of a soft-metal ring *A*, of U cross-section, filled with elastic fibrous packing *B*, consisting of woven asbestos tape (unless other material is desired), as shown in Figs. 1 and 2, the fibrous filling extending beyond the metal edges to prevent their becoming bent. The pressure exerted by the steam or other fluid in the pipe compresses the packing into the ring and this causes the ring to tend to expand and render the joint tight. When the pressure is off and the pipe begins to cool the resiliency of the fiber, as reaction sets in, serves to maintain the expansion in the ring and prevents the joint from leaking. These ring gaskets are made to fit the flanges just inside of the bolts, with which they are in contact and thereby held in position.

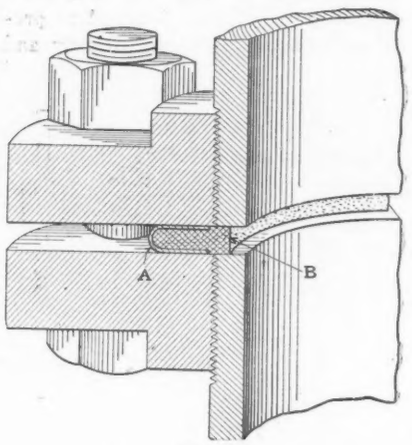


FIG. 2

For Van Stone and similar joints a small wire guard is attached, as indicated in Fig. 3, the guard resting against the bolts, thus holding the gasket in position. These gaskets are made by the E. A. Wilcox Manufacturing Company, 221 East Sixty-third street, Chicago. The company also makes gaskets in oval form for hand-hole, manhole and tank plates, and in other shapes for valve bonnets, steam chests, etc.

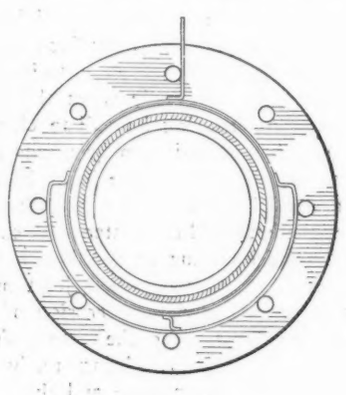
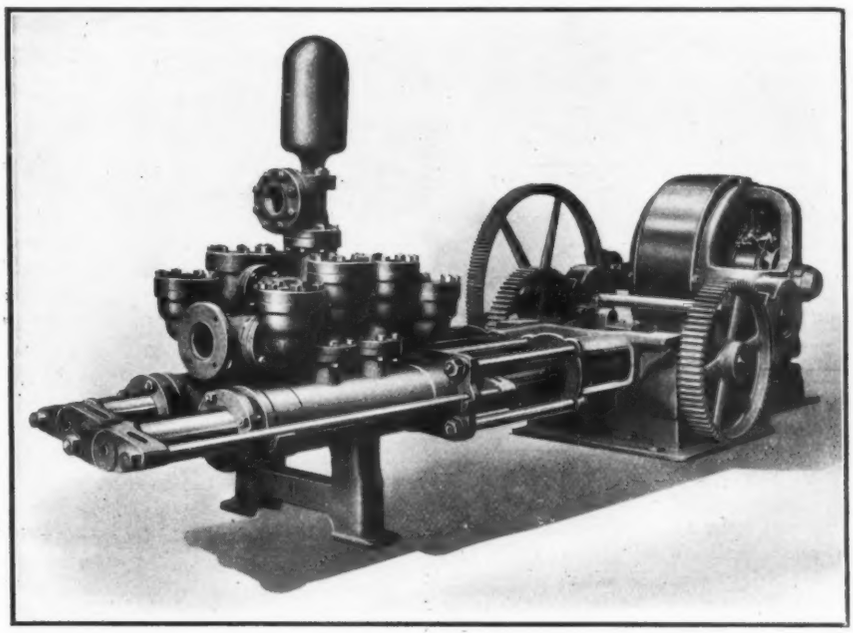


FIG. 3

Electrically Driven High-lift Pump

The pump here shown has outside, end-packed plungers. The plunger guide-rods run in babbitted boxes that may be renewed in case of wear. The pump valves are in pots and are easily accessible through the large lids. All pots are removable. The valve area is unusually large, which will explain the large size of the pots. Both inside and outside plungers can be easily removed without disturbing the cylinders or frame. The cranks are made of heavy steel, and are double so that pin is supported on both ends. The crank-shaft bearings are large and adjustable, and the shaft has three bearings. There are gears at both ends of shaft so that it is driven, not from one end but from both ends. The gears are all cut from the solid metal, and all the pinions are incased. The motor, the gears and crank-shaft are supported on a heavy bed casting.

The pump is designed especially for draining mines, and is made to raise water 450 feet vertically. It is manufactured by Dean Brothers' Steam Pump Works, Indianapolis, Ind.



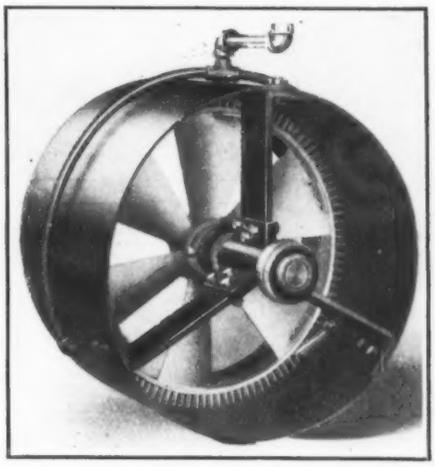
ELECTRICALLY DRIVEN HIGH-LIFT PUMP

"Lowndes" Patent Duplex Wrench

The "Lowndes" wrench is made by D. P. Brown & Co., 262 North Fourth street, Philadelphia. The accompanying illustrations leave very little to be desired in the way of description. As will be seen, the parts are few, there are no springs, and the wrench can be easily and quickly adjusted for use in any position. The cage which holds the adjusting nut which engages the movable jaw is pivoted to allow a Stilson-wrench effect. The operation of the wrench is positive and its construction apparently as durable as it is simple.

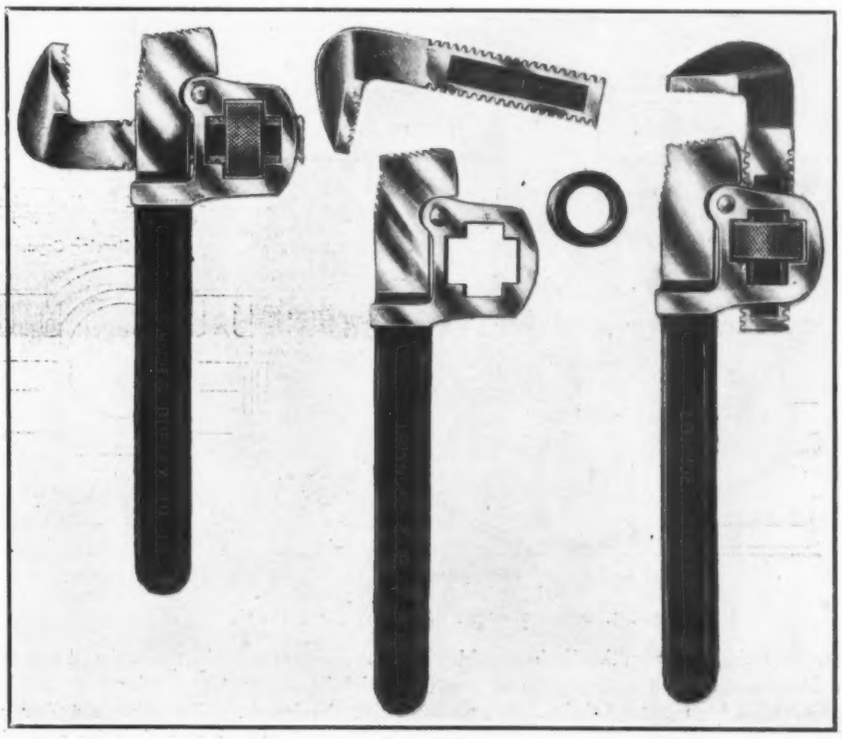
Wing's Turbine Fan for Mechanical Draft

Wing's turbine fan is the invention of L. J. Wing, president of the L. J. Wing Manufacturing Company, of New York City. The blades of this fan are practically the same type as those of the Wing disk fan, which is used for ventilating purposes. The turbine feature consists of a series of buckets attached to a band or ring which forms, in effect, the periphery of the blade tips, as shown in the illustration. Steam admitted through two or more nozzles of special design impinges upon the buckets and causes the fan to rotate. Only a small quantity of steam is required and this, after practically expending its energy in driving the fan, exhausts directly to the atmosphere.



WING'S TURBINE FAN

These fans are frequently used for mechanical draft for boilers, being incorporated in the side- or rear-wall setting, just below the grate. They are simple in construction and correspondingly strong. There are no real wearing parts other



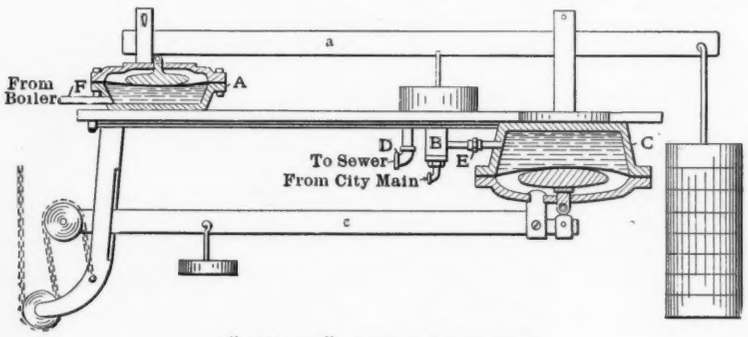
LOWNDES PATENT DUPLEX WRENCH

than the ball bearings, and beyond lubricating the bearings once a month the fan requires little or no attention.

"Economy" Damper Regulator

In the "Economy" damper regulator, which is illustrated herewith and which may be classed among the relay type of apparatus, the levers which operate the chain that controls the damper are actuated indirectly by boiler pressure and directly by the pressure of water against the diaphragms in the chambers *A C*. Water of condensation is used in the chamber *A*, while the chamber *C* contains water from the city main or from the discharge side of a feed-pump. When the entering steam pressure is high enough the condensed water in the chamber *A* presses against a rubber diaphragm, shown extending across the chamber, until the pressure overbalances the weights on the farther end of the lever *a*, when a small double-acting valve in the chamber *B* will lift and allow the water from the city main or other outside source to pass through *E* into the chamber *C*. The pressure on the diaphragm in the latter actuates the lever *c*, which action operates the chain and closes the damper in the stack.

As soon as the entering steam pressure at *F* drops one-half pound below what it was when the valve in *B* lifted, the valve reverses and allows the exhaust *D* to open, when enough water will exhaust from the chamber *C* to permit the lever *c* to resume its normal position, slacken the chain and open the damper. The diaphragms press against disk-faced plungers which have roller-bearing connections with the levers. The valve chamber can be cleaned out at any time by removing the steam lever *a* and the weights and unscrewing the top of the chamber *B;* then turn on the water and wash out the chamber.



"ECONOMY" DAMPER REGULATOR

The "Economy" damper regulator is made by S. B. Doolittle & Son, Binghamton, N. Y.

Main Bearing for a Steam Engine

Frank H. Crafts, of the Crafts Machine and Tool Company, of Buffalo, N. Y., has brought out a new automatic engine, the feature of paramount importance in which is the journal box or boxes to carry the crank-shaft. Referring to Fig. 1, the outer cheek *A* of the box is cast solid to the bed of the engine, the cap *B* is secured to *A* by means of a lug *D*, which fits into a pocket *C* in the member *A*, and when the box is clamped together a set-screw is brought to bear on the lug *D* and the box is firmly locked into position. In the event of re-adjustment being necessary from wear, the two cap-screws *A A*, Fig. 2, are loosened and the lost motion can be immediately taken out without any fitting or filing, or removing a screw even. The construction allows leaving a ¼-inch space between the cap and the bottom half of the box, into which space a strip of thick felt is inserted on each side of the crank-shaft upon which it bears. This felt acts as a sponge, holds the oil and feeds it to the journal as needed. The cap of the box is provided with large chambers packed with thick felt which serves to restrain the oil before it comes into contact with the journal and which insures freedom from grit. Another important feature is the extension of the bed which, it will be noted, extends 30 inches forward of the center line of the crank-shaft on a 12x12 engine. Fig. 3 shows the application of Mr. Crafts' idea to the journal of a lathe.

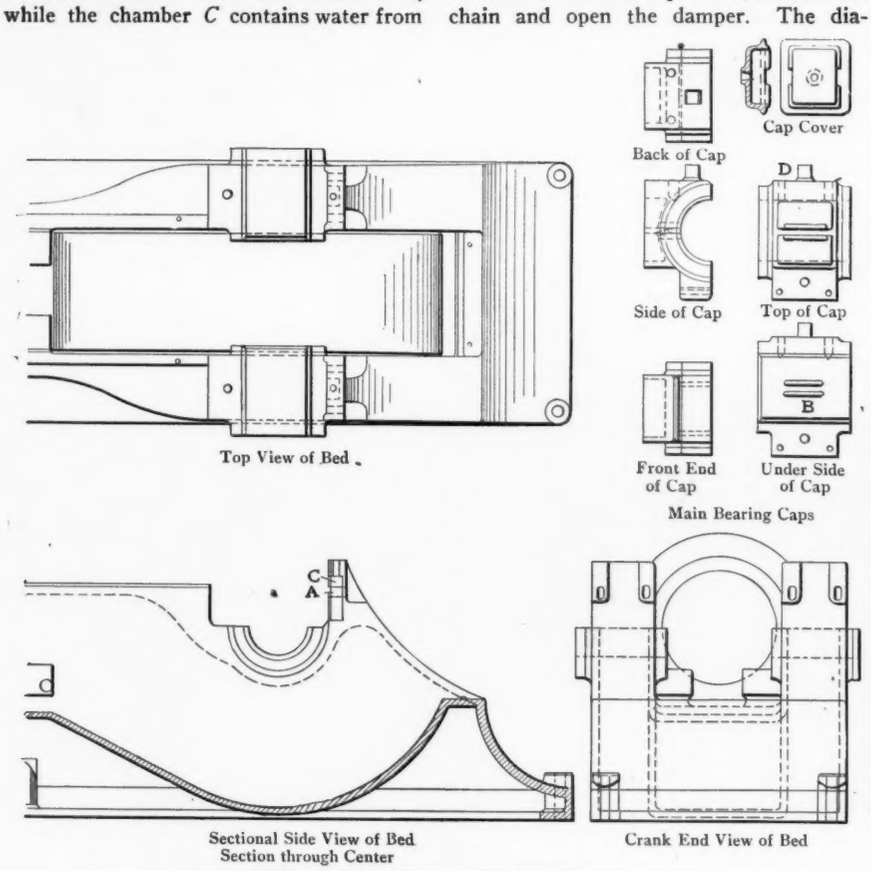


FIG. 1. DETAILS OF MAIN BEARING FOR STEAM ENGINE

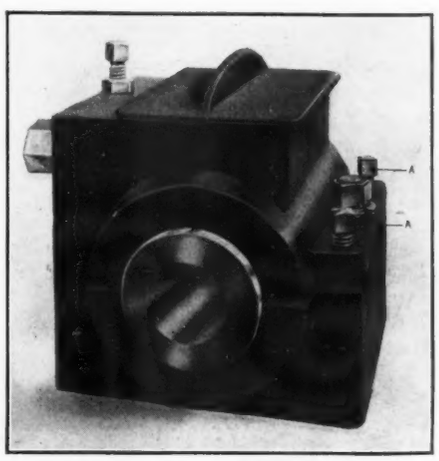


FIG. 2. SHOWING CAP-SCREWS FOR ADJUSTMENT

"De La Vergne" Two-stroke-cycle Oil Engine

The De La Vergne Machine Company, of New York City, has brought out a vertical oil engine, designed to use either ordinary kerosene oil or fuel oil. Fig. 1 shows the twin-cylinder type of this engine, with one half in section. The inlet port *A* and the exhaust port *E* in the cylinder at the lower end of the piston travel indicate at once that the engine operates on the two-stroke cycle and is single-acting, and as there are two cylinders the crank-shaft receives two impulses during each revolution. A leading characteristic of this engine is the method of ignition, which is performed by means of a hot vaporizing chamber similar to that of the well-known "Hornsby-Akroyd" oil engine, which this company also builds. The vaporizer is a bulb-shaped extension *V*, opening into the main cylinder. The vaporizer is made of gun iron, and in starting the engine it is heated initially from the outside by means of a kerosene-oil blow-lamp; after the engine is started, the vaporizer is kept hot by the successive explosions. The heat of compression added to the high temperature of the vaporizer wall serves to ignite the full charge, which is sprayed into the vaporizer through the nozzle *N*. The oil is sprayed into the vaporizer as the piston is about to reverse its motion and begin the power stroke. Just before the end of the down stroke the exhaust port is uncovered by the piston to let the burnt gases escape to atmosphere, as usual in two-stroke-cycle engines, and an instant later the inlet port *A* is uncovered, permitting the inrush of the air from the crank case into the cylinder, thus scavenging and recharging the cylinder and the vaporizer at the same time.

On the upward stroke fresh air is drawn into the crank chamber through an automatic poppet valve, and on the down stroke this air is slightly compressed, which forces it into the air passage to the cylinder. The different events are so nicely timed, it is stated, that almost perfect combustion is secured and danger of pre-ignition is reduced to a minimum.

It is essential, of course, that the oil be forced into the vaporizer suddenly at the right time and in quantity to suit the load on the engine. This is accomplished by means of a small plunger which is under control of an ingenious governor mounted on the fly-wheel. This arrangement is shown in Fig. 2. The frame *F* is fastened with two studs concentrically to the inside of the fly-wheel, and to the frame is hinged a cam-ring *R* which has on the fly-wheel side a projection *B*, and back of that the cam projection *C*, which lifts the roller *A* once each revolution of the fly-wheel, thereby actuating the oil-pump plunger *P*. The length of stroke imparted to the plunger is determined by the lever *L*, pivoted to the frame. A wedge *W* on the lever *L* separates the cam-ring from the frame *F*. When the engine is started the governor does not come into action until normal speed is approached. A decrease in load will cause the speed to increase, when the centrifugal force in the counterweight *K* will overcome the tension of the spring *S*, moving the weight outward and thereby withdrawing the wedge *W*. The spring *E* keeps the roller *A* in contact with the cam-ring *R*, and when the wedge is withdrawn the buffer *G* cannot actuate the pump plunger. The knob *H* is used for injecting oil at the start, and the lock-nuts *N* serve for limiting the stroke of

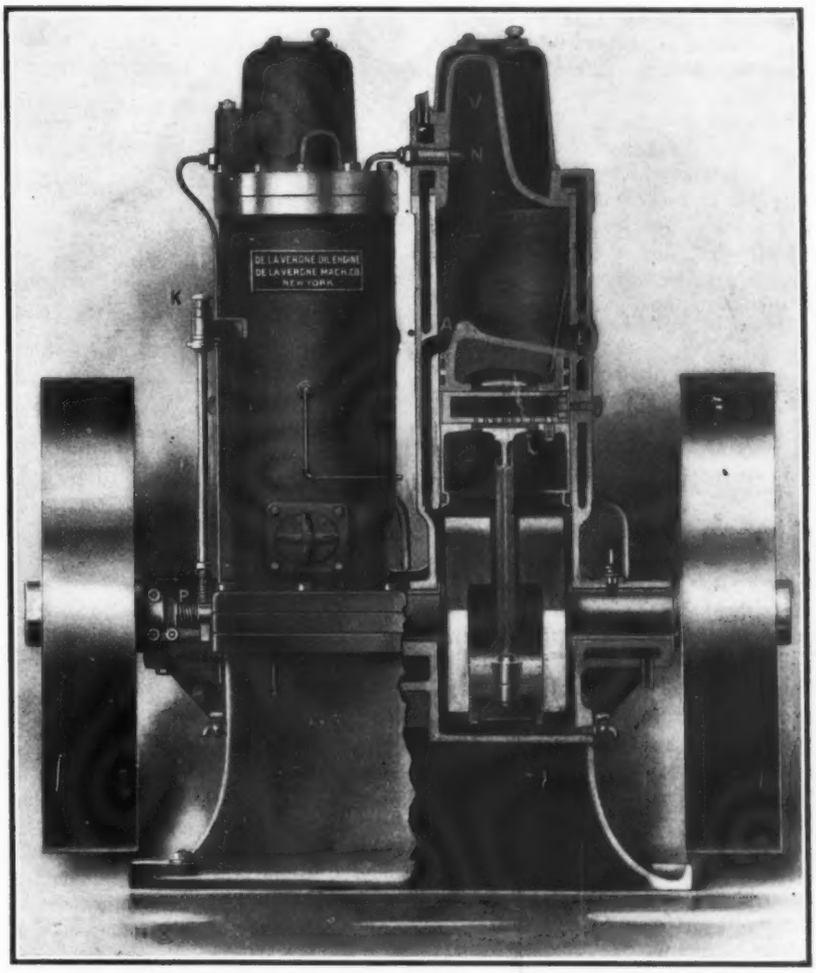


FIG. 1. TWIN-CYLINDER TYPE OF "DE LA VERGNE" KEROSENE-OIL ENGINE

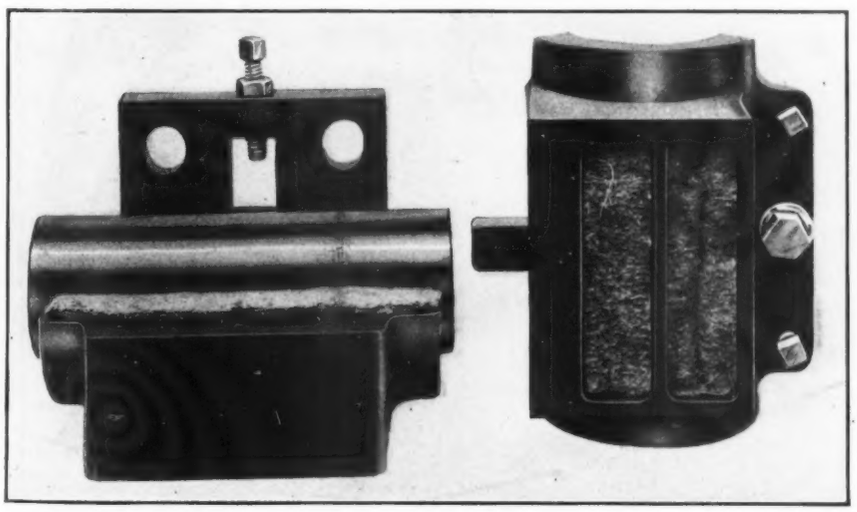


FIG. 3. APPLICATION OF CRAFTS' BEARING TO LATHE JOURNAL

the pump. The two concentric slots in the frame *F* allow for adjustment when it is desired to greatly change the normal speed of the engine. For smaller speed variations the spring *S* and the weight *K* can be shifted in the holes of the lever *L*.

Fig. 3 shows a section of the steel oil-spray nozzle. This rarely requires cleaning, as the pressure of the oil as it is forced through the deep grooves shown serves to keep the grooves clean. However, the nozzle can be taken out, cleaned and replaced in a few minutes. A steel-ball check-valve prevents the explosion from firing back into the oil pipe. The entire nozzle is located within a water-cooled section of the vaporizer wall.

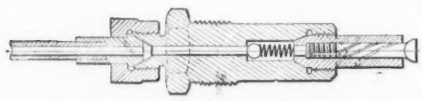


FIG. 3. SECTIONAL VIEW OF THE NOZZLE

The cylinder and bearings are water-cooled. A small rotary pump driven by spur-gear on the shaft circulates the water first through the crank case and around to the bearings, then through the two cylinders and the heads, around the spray nozzle.

The crank-shaft is a solid steel casting, with liberal bearing surfaces. The balance weights are cast on, so they cannot become loose, a design calculated to reduce vibration to a minimum. To lubricate the crank-pins a centrifugal oil-ring is turned out from the solid of each crank, with a straight oil-hole so disposed that it is always kept clear by the action of centrifugal force. There are no oil cups used on the engine, oil being supplied to the cylinders and all bearings, except the wrist-pin, from one force-feed central oiler actuated from the crank-shaft. The oil reservoir is filled once a day. The wrist-pin contains an oil receptacle which holds enough oil for several weeks' running. It is refilled through the side of the cylinder.

The two outer shaft-bearings and the lower half of the center bearing are lined with special bearing metal. The upper half of the center bearing is of phosphor bronze. Bronze spring packing-rings are used in the outer bearings to prevent loss of air, or leakage of lubricating oil along the shaft. The connecting-rod is of cast steel with a phosphor-bronze cap, and with special bearing metal at the crank end and bronze bushings at the wrist end.

It is stated that the vaporizer need not be cleaned oftener than twice a year, if the engine is run on kerosene oil. The 15-brake-horse-power size, which is shown herewith, weighs complete 1180 pounds, and the 7½-brake-horse-power size (single-cylinder) weighs 750 pounds without the base. The cylinders are each 7 inches in diameter, with 7½ inches stroke. The normal speed is 450 revolutions per minute. The engine can be run in either direction without changing any part.

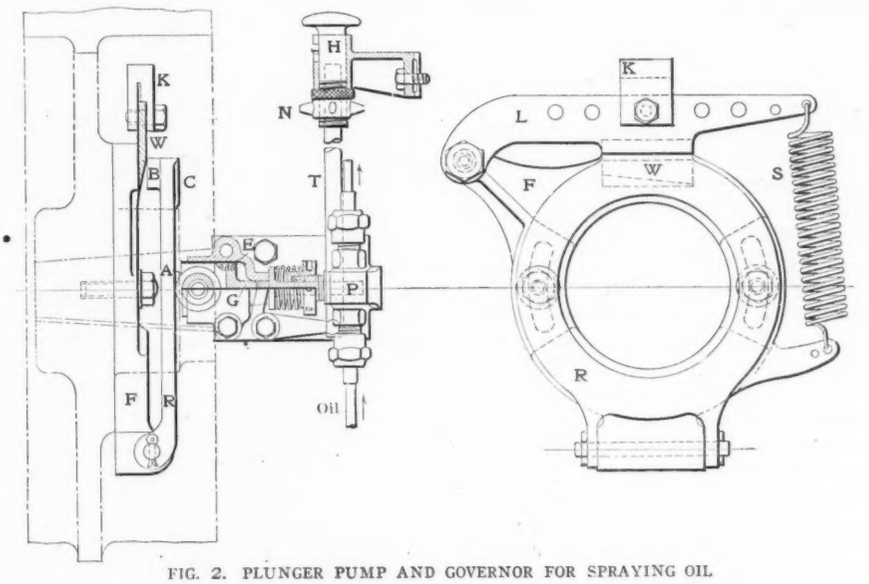
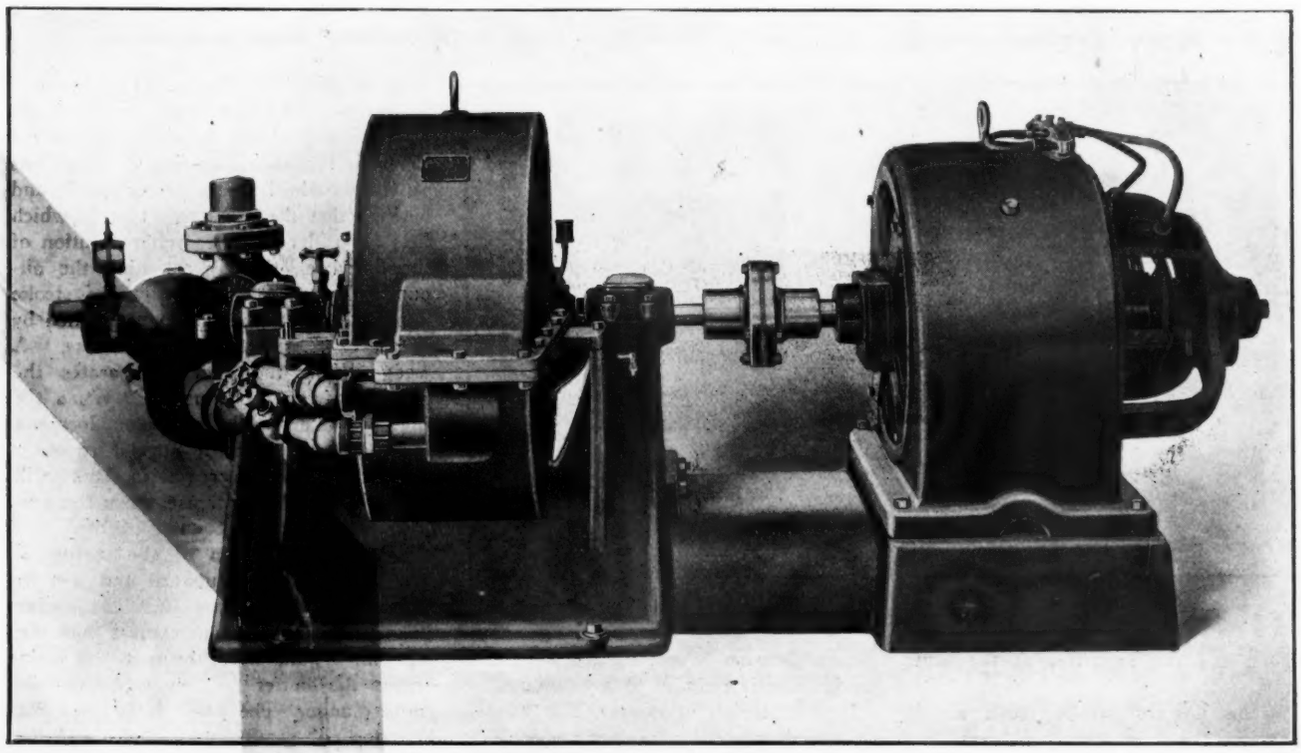


FIG. 2. PLUNGER PUMP AND GOVERNOR FOR SPRAYING OIL



A 50-KILOWATT TERRY STEAM-TURBINE UNIT

The Terry Steam Turbine

This turbine is of the Riedler-Stumpf type, the jets impinging tangentially and the steam being reversed by stationary guide-buckets and directed several times upon the buckets of the same runner. These stationary buckets, or reversing chambers, are inserted in the case of the turbine in groups of four, as shown in Figs. 1 and 2, each group being supplied by a divergent nozzle, designed for a complete expansion of the steam between the initial and condenser pressures. The steam entering the runner, which is shown separately in Fig. 4, at the left side of the bucket as shown in Fig. 3, is reversed by the bucket which passes it to another stationary guide by which it is reversed and again directed upon the wheel, and so on to the end of the series when the steam, with the greater part of its velocity abstracted, passes out into the case, whence it is exhausted to the atmosphere or condenser. A portion of the steam is returned from the bucket into which it is delivered into the reversing chamber alongside the jets and enters the buckets again with the new steam, and may make several circuits as indicated by the dotted lines, but as it loses velocity it nears the center of the bucket, in which there is a crescent-shaped opening, allowing it to pass to the next stage. In order to allow sufficient area for the passage of the jet with the decreasing velocity the cross-sectional area of the stationary buckets is progressively increased.

With this sub-division of the process of abstracting the energy of the steam, the peripheral velocity of the runner may be kept down to about 250 feet per second, so that turbines from 10 to 150 horse-power are lifted at 2500, and those from 120 to 300 horse-power at 1650 revolutions per minute. They are made by the Terry Steam Turbine Company, Hartford, Conn.

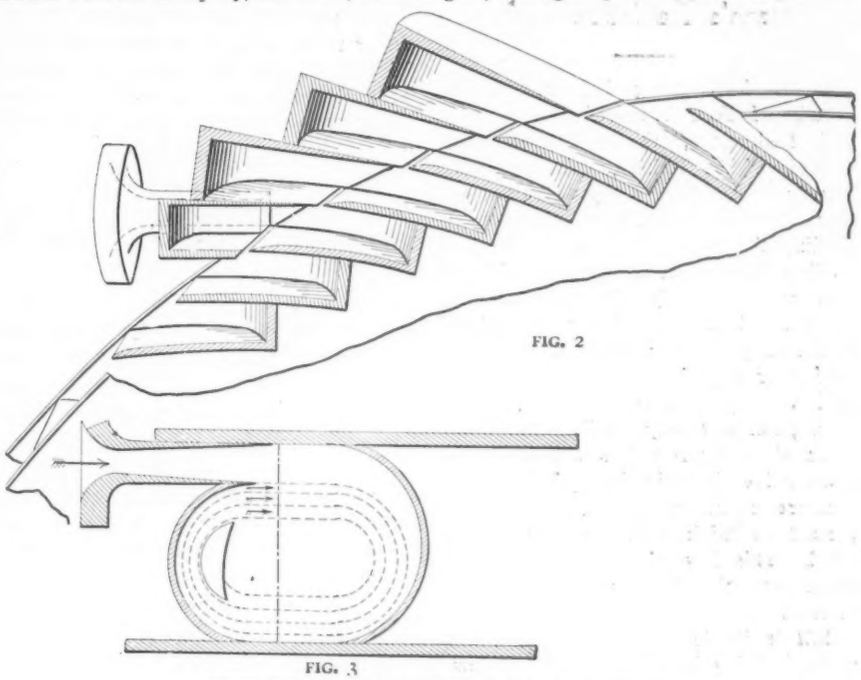


FIG. 2

FIG. 3
SHOWING PRINCIPLE OF TERRY STEAM TURBINE

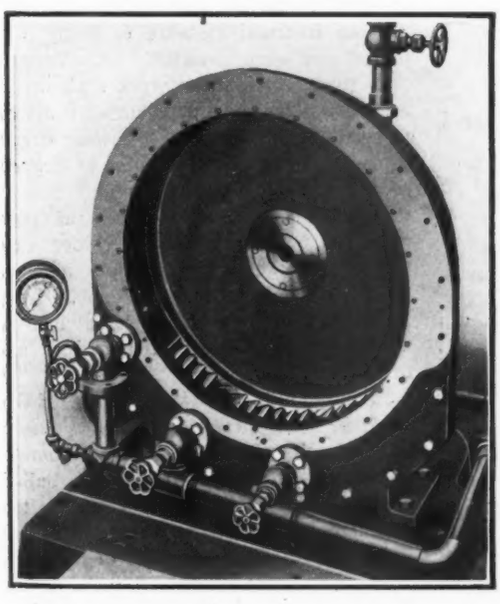


FIG. 1. SHOWING THE STATIONARY BUCKETS

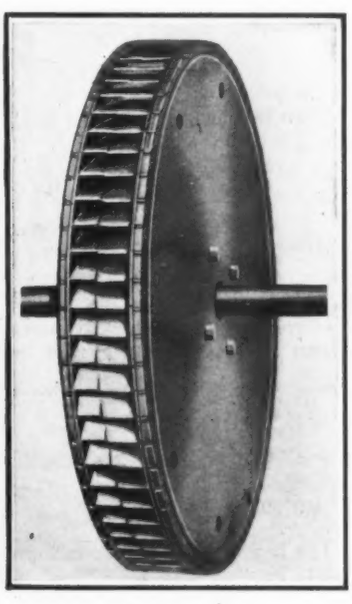


FIG. 4. ONE OF THE RUNNERS

"OxoilOx"

This is a belt dressing made from neatsfoot oil pressed from the hoof and refined by the F. S. Walton Company, of Philadelphia. The process by which the finished product is obtained is rather interesting. Briefly, the fats from the feet of cattle ("neat" being the old English word for cattle) are first rendered and the stock so obtained is pressed for the yield of oil (neatsfoot), producing what is known commercially as hoof stock, or "pure neatsfoot." This hoof stock is then "grained" or "seeded," placed in cold storage and frozen to the necessary degree, and again pressed, producing a comparatively small percentage of a very low cold-test neatsfoot oil, practically all the stearine or solid matter having been eliminated. Then comes a further refinement, followed by sun bleaching, resulting in a water-white oil, which will remain limpid when subjected to a temperature of 20 degrees Fahrenheit. Finally, a special treatment is applied which radically changes the appearance while retaining the good qualities, with the addition of others designed to enhance the preservative characteristics.

"OxoilOx" is warranted free from rosin and other deleterious substances. It is put up in 8-, 16-, 40- and 80-pound cans, half barrels and barrels.

Important A. S. M. E. Meeting

The American Society of Mechanical Engineers will hold its next regular monthly meeting on Tuesday evening, November 12, at 8:15 o'clock, in the building of the Engineering Societies, 29 West Thirty-ninth street, New York.

The principal address will be by Charles R. Pratt and will treat of features of construction and operation of the "Gearless Traction Electric Elevator," which is being installed in the Singer and Metropolitan Life, New York's two highest, buildings. The paper will be discussed by engineers and architects from New York, Philadelphia and Chicago. It is expected that the subject will be very exhaustively treated from the view of the architect and the engineer. The members of all professions are cordially invited to attend.

The Practical Engineering Importance of Steffan and Boltzmann's Radiation Law

In a forthcoming bulletin entitled, "Study of Four Hundred Boiler Tests, with Deductions," the steam-engineering division of the United States Geological Survey treats of the lately developed and proved law of Steffan and Boltzmann regarding the total radiation of heat (including light) from a hot to a cold body.

It was formerly thought that the amount of heat radiated was proportional to the temperature difference. Inasmuch as former experimental work was done at low temperatures, the error of this assumption was very small. But of late years since interest has arisen in the quantitative investigation of high-temperature furnaces, it has become important to think with the true law in mind. This law of Steffan and Boltzmann states that if two infinite plane surfaces are close together, or, better yet, if a ball is inside a hollow sphere, both surfaces being in all cases of the same material, in the same state of surface finish, the rate of heat radiation from the hotter to the cooler surface is:

$$Rate\ of\ Radiation = K\ (T_1^4 - T_2^4),$$

where

K = Constant for any particular set of bodies and surfaces,

T_1 = *Absolute* temperature of the hotter body,

T_2 = *Absolute* temperature of the colder body.

The above equation is equivalent to stating that each body radiates heat and receives heat by radiation; that the rate of radiation from each body is proportional to the fourth power of its absolute temperature; and therefore that the net amount of heat given up by the hotter body to the cooler one is proportional to the difference of the fourth powers of their absolute temperatures.

The forthcoming bulletin makes a number of applications of this law. Some similar applications are given below.

Examples

In a Heine water-tube boiler having the lower row of tubes over the furnace completely incased in clay tiles, excepting about three feet at the rear end over the combustion chamber, this exposed three feet of tubes absorbs heat not only from convectional contact with the gases entering the boiler, but also from intense radiation from the white-hot combustion-chamber walls and bottom.

The soot covering of the water tubes is of a different surface and finish from the surface of brick and slag constituting the combustion-chamber walls and bottom; nevertheless, the above equation will hold approximately, and some examples are given to show the enormous increase of this radiation factor with rise of combustion-chamber temperature.

Let the soot on the exterior of the water tubes have an average temperature of 1239 degrees Fahrenheit — a dull-red heat. Adding 461 degrees Fahrenheit to get the absolute temperature we have

$$T_2 = 1700\ degrees.$$

Assume the rear-furnace temperature to be 2039 degrees Fahrenheit, a rather poor condition of operation. Adding 461 degrees to 2039 degrees we have

$$T_1 = 2500.$$

Then, the net heat received by the tubes per second from the furnace bottom and sides =

$$K\,(T_1^4 - T_2^4) = K\,(2500^4 - 1700^4)$$
$$= K\ (30{,}710{,}400{,}000{,}000).$$

Let the average soot temperature be 1239 degrees Fahrenheit, or 1700 degrees Fahrenheit absolute, as before.

Then:

$$T_2 = 1700\ degrees.$$

Assume that the average rear combustion-chamber temperature is only 500 degrees higher than in the first example, that is, 2539 degrees Fahrenheit, a medium temperature; then:

$$T_1 = 3000\ degrees.$$

Then the net heat received by the tubes per second, from the furnace bottom and sides =

$$K\,(3000^4 - 1700^4)$$
$$= K\ (72{,}647{,}900{,}000{,}000).$$

Assume as before that $T_2 = 1700$ degrees absolute and raise the furnace temperature another 500 degrees Fahrenheit, to 3039 degrees, which would be wall temperature in quite a hot furnace. Therefore,

$$T_1 = 3500\ degrees.$$

Then the net heat received by the tubes, etc., =

$$K\,(3500^4 - 1700^4)$$
$$= K\ (141{,}710{,}400{,}000{,}000).$$

Summary of Examples

Dropping the constant K and the last twelve figures of every answer, we have:

Furnace Temperature. Degrees Fahr.	Tube Temperature. Degrees Fahr.	Number to which net radiation is proportional.
2039	1239	31
2539	1239	73
3039	1239	142

The heat absorbed from radiation practically doubles with every 500 degrees of increase in the combustion-chamber temperature.

As a matter of fact the temperature of the soot on the tubes rises a little as the furnace-wall temperature rises, and it is also a better radiator of heat than is the brick wall. Nevertheless the above examples are substantially correct.

Numerical Percentages

The foregoing calculations give no idea as to whether the percentage of heat received by a boiler from radiation is the larger or smaller portion of the whole. In the "Study" mentioned some numerical calculations are given, determined by two independent methods of approach. The results are probably right within 20 per cent.

It is evident, in the case of an ordinary multi-tubular boiler burning smokeless coal right under the boiler shell, that perhaps half of the heat enters the water from a radiation source. Even in water-tube boilers it may be about 20 per cent. In locomotive boilers the fire-box may sometimes absorb from 30 to 50 per cent. of the total heat absorbed, most of this being due to radiation.

Miscellaneous Applications of the Radiation Law

The engineers of the steam-engineering division were recently much surprised at the magnitude of thermometric errors due to radiation when measuring the temperature of dry gases. If the bulb of a thermometer have a chance to "look outdoors" when in a hot chamber surrounded by a flowing stream of hot gas, it may read 20 or 30 degrees low at the moderate temperatures of 500 or 600 degrees Fahrenheit; nor does the "window" have to constitute a very large percentage of the chamber walls in which the bulb is situated. Two thermometers a little over an inch apart in the same long chamber, swept by the same stream of hot air, were found to read nearly 100 degrees apart; a third one farther along, carefully closed in, read nearly as high as the first one. All the instruments were carefully calibrated and were repeatedly interchanged.

In superheated-steam work such errors are very persistent. It is no easy matter to get the temperature of a flowing stream of superheated steam within 10 degrees of the true temperature. It may be said that under such circumstances the thermometer bulbs are *always* colder than the steam; the only question is, how much? This fact alone will explain away many troubles engineers have had in working with superheated steam and other permanent gases.

In determining the temperature of flue gases in boiler practice the errors due to radiation of heat from the thermometer bulb are usually large. Unless the bulb is carefully protected from radiation by two or three concentric chambers around it, it is likely to read dozens of degrees low. A moment's reflection will make it evident that all surfaces ordinarily "visible" to the thermometer bulb are hundreds of degrees colder than the gases (and than the bulb). This is true of the brickwork, the adjacent water tubes and steam drums, the stack and the sky above.

Tests of Lubricants

The testing department of the William Cramp & Sons Ship and Engine Building Company conducted in September of last year, under the direction of C. R. Spare, a series of tests for the Keystone Lubricating Company, of Philadelphia, of Keystone grease as compared with other lubricants, solid and liquid.

On a bearing 3.5 inches in diameter and 3.5 inches long, running 450 revolutions per minute, giving a surface speed of about 442 feet per minute under a pressure of 107.1 pounds per square inch, it was necessary inside of an hour to discontinue the test with the first grease used, as the temperature rose to 200 degrees Fahrenheit, causing the grease to smoke. The friction reached 58.5 pounds on one observation and averaged 20 pounds, giving a co-efficient of 0.0133.

The tests were made upon a Cornell testing machine, the bearing of which was of standard shape, lined with Cramp's "Government Babbitt," and grooved diagonally and fed with grease from a hand-pressure cup of 3 ounces capacity, by applying a uniform pressure at five-minute intervals. Toward the end of the above test frequent additional applications of grease were made to keep the temperature within a safe limit.

The same bearing at the same rotative and rubbing speeds could not be run with the second grease tried with the pressure of 1500 pounds, or 107.1 pounds per square inch of projected section, on account of heating, so the load was restricted to 1000 pounds total, or 71.4 pounds per square inch. Even at this it was necessary to discontinue the test at the end of 30 minutes, with an average coefficient of friction of 0.0063.

With Keystone grease the same bearing at the same surface and rotary speeds carried the full load of 1500 pounds for a full hour, with an average coefficient of friction of 0.0056, and an increase in temperature during the hour from 160 to 174 degrees, the temperature of the room being 88 and the increase to 160 due to a preliminary run. In March of the present year the tests were repeated with other lubricants and with 3000 pounds upon the bearings, the speed and other conditions remaining the same. A well-known engine-oil ran an hour and three-quarters with an increase of temperature in the bearing from 66 degrees, the temperature of the room at starting, to 137, a rise of 61 degrees over the final temperature, 76 degrees, of the room. The average coefficient of friction was 0.00429. A well-known spindle-oil ran the bearing with the same load and speed 2 hours 35 minutes, with a rise of 68 degrees above the room temperature, and a coefficient of friction of 0.0457. A grease was tried, but it liquefied and ran, so that the pressure was reduced to 1500 pounds. At this load it ran the bearing for an hour and forty minutes, with an increase of temperature above that of the room of 66 degrees, and with an average coefficient of 0.00706, while Keystone grease ran it for two hours and a half with an increase in temperature of 64.2 degrees above that of the room, and a coefficient of 0.034.

Personal

Percy H. Thomas and N. J. Neall have formed a partnership, under the firm name of Thomas & Neall, as designing, supervising and consulting electrical engineers, with offices at 52 William street, New York, and 12 Pearl street, Boston.

Charles W. Naylor, consulting engineer for Marshall, Field & Co., and past national president of the N. A. S. E., has again been appointed instructor of the class in steam engineering at the Association Institute of the Y. M. C. A., Chicago.

R. E. Mathot, of Brussels, Belgium, gas-engine expert, will sail shortly for Quebec, Can., thence journeying by rail to New York. Mr. Mathot is scheduled to read a paper at the December meeting of the American Society of Mechanical Engineers on "Valve-gears and Systems of Governing of European Gas Engines."

John C. Ostrup has been appointed professor of structural engineering at Stevens Institute of Technology. Professor Ostrup was graduated at the polytechnic school at Copenhagen, Denmark, and took a post-graduate course at Chicago, Ill. During the past seventeen years he has been designing elevated-railroad structures and bridges, or practising his profession privately.

Prof. Charles H. Benjamin has been appointed dean of the schools of engineering of Purdue University, La Fayette, Ind., to succeed W. F. M. Goss. Since 1899 Professor Benjamin has been professor of mechanical engineering at the Case School of Applied Science. Prior to that he was engaged in engineering practice for three years, and for six years was instructor and professor of mechanical engineering at the University of Maine, of which he is a graduate.

The advisability of using feed-water heaters in connection with steam fire engines was discussed by James W. Jantzen, an engineer in the fire department of Lowell, Mass., at the 28th convention of the Massachusetts State Firemen's Association. By using a copper coil in the uptake he had produced a remarkable improvement in the capacity and steaming qualities of one of the engines of the department.

Heating Boiler Feed-water

"Heating Boiler Feed-water where the Main Engine Is Run Condensing" is the title of a treatise recently published by the Harrison Safety Boiler Works, Philadelphia, Penn. It is shown that by using the exhaust steam of boiler feed-pumps, circulating pumps and air pumps for pre-heating the boiler feed-water, the efficiency of these pumps becomes much higher than that of the best triple-expansion, condensing engine. At the same time, steam-driven machines of this character are much less expensive in first cost and the cost of attendance, are less liable to get out of order and may be operated when the main engine is standing idle, which, of course, is not the case with directly connected or electrically driven auxiliaries. The illustrations and text cover the engineering phases of the subject, including methods of operating barometric and surface condensers, the effect of air in the condensers of steam turbine plants, description of a typical street railway power plant, etc. Copies of this booklet will be supplied upon application.

The 16th annual (1907) edition of "Hendricks' Commercial Register of the United States, for Buyers and Sellers," has just been issued and compared with previous editions it shows marked improvement, in addition to being the largest volume yet published. The first edition, issued in 1891, contained about 500 pages, while the present edition numbers more than 1300 pages and contains upward of 350,000 names and addresses classified under 31,212 trade headings. The first edition required only 8 pages for an index, the 1906 edition required 62 pages, and the index of the 1907 edition comprises 76 pages. The classification covers the building, engineering, mechanical, railroad, electrical, mining, iron, steel, export and kindred industries of the country. It is the only publication issued that is so classified and it can be used for either purchasing or mailing purposes. It costs $10 and is expressed to any part of the United States upon receipt of price. It is published by the S. E. Hendricks Company, 74 Lafayette street, New York City.

"The Belt Book" is the title of an attractive little house organ issued by Charles A. Schieren & Co., New York. The number before us contains some interesting historical matter on the tanners of Neiuw Amsterdam upon the Making of a Belt, numerous illustrations of large and remarkable belts and illustrated instructions how to and how not to Lace a Belt. It will be sent regularly upon application to the main or any branch office of the company.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Approximate Power in an Unbalanced Three-phase Circuit

How can we estimate the approximate horse-power in a three-phase primary incandescent-lighting circuit when the circuit is slightly unbalanced? The primary currents are 30, 32 and 34 amperes per wire, respectively, and the electromotive force is 2300 volts. C. E. H.

Multiply the average current per wire by the voltage and by 1.732. Thus, in the case you specify, the average current is

$$\frac{30 + 32 + 34}{3} = 32$$

amperes, so that the approximate electrical power in the circuit is

$$32 \times 2300 \times 1.732 = 127{,}475.2$$

watts. The approximate electrical horse-power, therefore, is

$$\frac{127{,}475}{746} = 170.87.$$

This is based on an assumption of unity power factor, but as the power factor would probably be around 97 or 98 per cent., and the calculation is only approximate by reason of taking the arithmetical average of the three currents, it is scarcely worth while to consider the power factor. The only practical method of ascertaining accurately the true power in an unbalanced three-phase circuit is by means of two single-phase wattmeters or watt-hour meters, or one three-phase meter.

What Will Be the Effect of Increasing Weight of Governor Balls?

If the weight of the balls is increased in the fly-ball governor, what effect will it have on the speed of the engine? D. J. O'R.

In regard to the effect of the weight of the balls on a centrifugal governor of the pendulum type, the action of such a governor is controlled by the relation of two forces, gravity and centrifugal force. The mass involved enters into both of these forces. If you increase the weight of the balls you increase their tendency to hang downward by reason of the greater weight, but you increase equally their tendency to fly outward, by reason of the greater centrifugal force, due to the greater mass, so that for the purely abstract case the balls would revolve in the same plane for the same number of revolutions per minute, whatever their weight; and the angle of the arms would be the same at the same speed if the balls were entirely detached, except as the position of the center of gravity is affected. This simple proposition is somewhat modified in practice by the fact that the governor has work to do. If there were no mass to the balls and the arms there would be no energy available for operating the latches and overcoming the resistance to movement of the governing mechanism. There must, therefore, be sufficient weight in the revolving parts to effect these results without serious displacement, and if the weight is restricted beyond this point it may have a serious effect upon the speed of the engine.

To Figure Air-cylinder Slippage from the Indicator Diagram

How is the slippage of the air cylinder on a blowing engine determined from the indicator diagram? Is it indicated by the distance from the end of the atmospheric line to the point where the inlet valve opens, as shown in the accompanying sketch? E. S.

In your diagram from the air cylinder the line corresponding to the compression line of a diagram from the steam cylinder ought to lean to the left and not be perpendicular as you have drawn it. It is made by the air in the clearance re-expanding as the piston moves away, so that it takes the shape of a compression line,

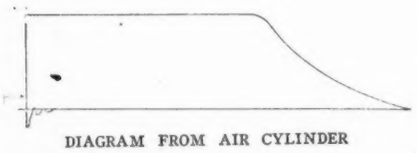


DIAGRAM FROM AIR CYLINDER

and until this air has expanded below this atmospheric pressure, no new air can be drawn in; so that the stroke measured on this expansion curve and at the hight of the intake line ought to give you the slippage.

Graduations of a Mercury Tube

Why is the mercury tube used on a blast-furnace engine graduated in sixteenths of an inch, each sixteenth being intended to represent one ounce pressure per square inch? As one cubic inch of mercury weighs 0.89 pound, it seems as if it ought to take nearly two inches to counterbalance sixteen ounces of pressure. E. S.

It takes about two inches of mercury to balance a pound pressure, which would make about ⅛ of an inch to balance an ounce pressure, but the pressure in a U-tube is measured by the difference in level of the columns in the two legs, and it requires a movement of only 1/16 of an inch in either leg to produce a difference of level of ⅛ of an inch.

To Reset a Vacuum Gage without Using a Test Gage

In removing our gage board from one part of the engine room to another, the pointer or hand on the vacuum gage dropped off the pin. Is there any way by which the vacuum gage can be reset accurately without using a test gage? The plant is quite isolated, and having no test gage, it will prove quite expensive to get one. G. W. S.

If you disconnect the gage and put the hand around so that it will stand at zero, while the gage is open to the atmosphere, will it not be as correct as it was before the accident happened?

Atmospheric Pressure at High Altitudes

What is the atmospheric pressure 10,000 feet above sea level? W. C. C.

Ten pounds per square inch. For any other altitude, multiply the hight by 0.00047 and subtract the result from 14.7 to get the pressure per square inch.

Mechanical Equivalent of Heat

What is meant by the statement that "the mechanical equivalent of heat is 778 foot-pounds?" W. K. S.

Here is one form of energy, the English unit of which is the British thermal unit, commonly referred to as the "heat unit." This is the unit of quantity, not temperature, and one unit of heat energy will do the same amount of work as 778 foot-pounds of mechanical energy. Hence, the "mechanical equivalent" of one heat unit is 778 foot-pounds. Heat is converted into mechanical energy by the expansion of the substance containing it, as in the case of steam behind an engine piston; when the steam expands sufficiently to reduce the heat in it one B.t.u., it imparts to the piston 778 foot-pounds of mechanical energy.

Increasing Small Power-plant Ability

A 75-kilowatt alternator driven by a non-condensing engine fails to keep the voltage up during the load peak, which is about 88 kilowatts. What is the best way to increase the output ability to carry the peak? If an additional generating unit were installed, what size would be advisable? H. B. B.

If the alternator will stand it, and the voltage drop is due to a decrease in engine speed, the addition of a condensing equipment will probably meet the difficulty. If the alternator overheats during the load peak, either a larger one must be substituted or an additional unit installed. If there is any prospect of growth of the service, an additional unit should be put in anyhow, and should preferably be exactly like the one now in service for convenience in interchanging them during moderate loads and in carrying spare parts on hand.

Turbine and Engine Auxiliaries

Which requires the heavier equipment of auxiliaries, per pound of steam used in the main units, a plant of reciprocating engines or one of steam turbines? T. C. N.

The turbine plant, because a higher vacuum is carried and the condenser-pump work is correspondingly greater. And if the turbine is vertical, the step-bearing pump is entirely additional.

New Catalogs

F. E. Keyes & Son, 20 Broad street, New York. Folder. Advance feed water purifiers. Illustrated.

Earl Canedy, Chicago Heights, Ill. Catalog. Canedy pumping engine. Illustrated, 12 pages; 3½x6 inches.

Murphy Iron Works, Detroit, Mich. Catalog. Automatic smokeless furnace. Illustrated, 40 pages, 6x9 inches.

Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburg, Penn. Catalog. No. 9. Steam and water specialties. Illustrated, 56 pages, 5½x8 inches.

H. W. Johns-Manville Company. Catalog No. 110. Morris metallic packing. Illustrated, 14 pages, 4½x7 inches.

Termaat & Monahan Company, Oshkosh, Wis. Catalog. Reversible marine engines. Illustrated, 28 pages, 4x9 inches.

The Triumph Ice Machine Company, Cincinnati, Ohio. Catalog. Refrigerating compressor. Illustrated, 64 pages, 6x9 inches.

The Loew Manufacturing Company, Cleveland, Ohio. Catalog. Boiler feed water heaters. Illustrated, 36 pages, 5x6½ inches.

The Goulds Manufacturing Company, Seneca Falls, N. Y. Booklet. Triplex power pumps. Illustrated, 48 pages, 4½x8½ inches.

Ross Steam Specialty Company, 140 Cedar street, New York. Catalog. High and low water alarms. Illustrated, 8 pages, 3½x6½ inches.

The Watson-Stillman Company, 25 Dey street, New York. Catalog No. 72. Twin-volute turbine pumps. Illustrated, 48 pages, 6x9 inches.

Oswego Boiler and Engine Company, Oswego, N. Y. Catalog. Oswego-McNaull water-tube boilers. Illustrated, 24 pages, 6x9 inches.

Detroit Leather Specialty Company, 25 Beecher avenue, Detroit, Mich. Catalog. Wear well leather packings. Illustrated, 32 pages, 7x9 inches.

Wm. B. Scaife & Sons Co., Pittsburg, Penn. Catalog. Scaife and We-Fu-Go systems of water purification. Illustrated, 96 pages, 8x10 inches.

H. W. Johns-Manville Company, 100 William street, New York. Catalog. Victor combination meters. Illustrated, 34 pages, 4½x7 inches.

Chain Belt Company, Milwaukee, Wis. Catalog No. 35. Elevating, conveying and power transmitting machinery. Illustrated, 288 pages, 6x9 inches.

York Manufacturing Company, York, Penn. Bulletins. Single and double-acting and absorption ice-making and refrigerating machines. Illustrated.

Ingersoll-Rand Company, 11 Broadway, New York. Leaflet, Form 53A. Economical machinery for the coal mine. Illustrated, 24 pages, 3½x5½ inches.

Northern Specialty Company, 63 Columbia street, Utica, N. Y. Catalog No. 3. Northern self-closing safety water gage. Illustrated. 12 pages, 6x9 inches.

The Waterbury Farrel Foundry and Machine Company, Waterbury, Conn. Catalog, Section H. Hydraulic presses, pumps, valves, accumulators, etc. Illustrated, 152 pages, 6x9 inches.

Fort Wayne Electric Works, Fort Wayne, Ind. Bulletin No. 1094. Belted direct-current generators, Type LF. Illustrated, 8 pages, 8x10½ inches. Bulletin No. 1096. Type A transformers. Illustrated, 8 pages, 8x10½ inches.

New Equipment

The Planters Oil Company, Albany, Ga., contemplates installing an ice plant.

The Clay City (Ind.) Lighting Company will construct an electric lighting plant.

The city of Fairview, O. T., has voted $25,000 bonds for the construction of water works.

The Ida Grove (Iowa) Electric Company, is contemplating remodeling and extending its plant.

A new boiler house is being erected at the plant of the Citizens' Gas Company, Kankakee, Ill.

The city of Meridian, Miss., has voted $50,000 of bonds to improve and extend the water works.

The Conestoga Traction Company, Lancaster, Penn., will erect a new power house and car barn.

The electric light plant of the Laurel-Seaford Electric Company at Laurel, Del., was destroyed by fire.

The electric and compressed-air plant of the Webb Granite Company, Milford, Mass., was destroyed by fire.

W. R. Scammahorn, Heizer, Barton county, Kansas, would like catalogs of engines, turbines, pumps and boilers.

The plant of the Oakland (Cal.) Gas, Light and Heat Company was damaged by fire, causing a loss of $100,000.

The Union Typewriter Company, Bridgeport, Conn., has awarded contract for the construction of its new power house.

The Baker Light and Power Company is contemplating improving its plant at Rockcreek, Ore. Manager, A. Welch, Baker City, Ore.

The electric light plant and pumping station at Waynesboro, Va., were completely destroyed by fire. W. A. Rife owned the plants.

The Wm. J. Lemp Brewing Company, St. Louis, Mo., is having plans prepared for a new boiler house, to cost, with equipment, $200,000.

Bids are being asked by the town council of Bicknell, Ind., for the construction and equipment of a combined water and electric light plant.

The citizens of Canton, Ga., voted in favor of issuing bonds for the establishment of an electric light plant, water works and sewerage system.

The Standard Ice and Light Company, has been organized at Magnolia, Ark., with $25,000 capital stock by A. L. Moore, J. O. Hutcheson and others.

An addition will be erected to the power house of the municipal electric light plant of Alameda, Cal., and new machinery installed. J. B. Kahn is superintendent.

The Northern Idaho Pine Lumber Company, Lane, Idaho, is contemplating installing an electric plant to run two saw mills and also light the town of Lane.

The Prineville (Ore.) Light and Water Company is contemplating installing a power plant on the Matoles next year to supply the county with electricity. Adrian Crooks, Prineville, is manager.

Miller Reese Hutchison, exporting engineer, 1 Madison avenue, New York, representing in the United States several foreign importing concerns, requests six catalogs and six export price lists of steam plant machinery and supplies, electrical machinery and supplies, gasolene, gas and oil engines, pipe fittings and pipes.

Business Items

The Trill Indicator Company, Corry, Penn., is sending out a circular advertising the Triumph indicator. The company asks no one to take chances on its products but will send them to any responsible person for ten days' free trial. If not exactly as represented, they are to be returned at the company's expense.

Among orders for foreign shipments recently received by the Buffalo Forge Company, of Buffalo, is one of special interest, covering a horizontal center-crank compound automatic engine, 13x20x14, for direct-connection to a General Electric Company's generator, this unit to be used for the electric illumination of the tower of Noshiro, on the northwest coast of Japan.

The Green Fuel Economizer Company, Matteawan, N. Y., has reprinted the paper read by R. D. Tomlinson before the New York Railway Club, entitled, "Fuel Economizers at the Manhattan Power Station of the Interborough Rapid Transit Company, New York City." The pamphlet is well illustrated and should be of interest to designers and operators of large steam plants. It may be obtained by addressing the Green Fuel Economizer Company.

Under the title, "Triumph Originality," the Triumph Ice Machine Company, of Cincinnati, Ohio, has issued a pamphlet which will appeal to the man who cares to know more about the machinery under his charge than can be seen from the outside. The catalog is illustrated with half-tone engravings, showing the details of the machine in sections, and is a great deal more than a catalog, in that it contains a mass of technical information of service to the refrigerating engineer.

The Youngstown Sheet and Tube Company, of Youngstown, Ohio, has just completed the purchase of two 1500-kilowatt Allis-Chalmers steam-turbine units for addition to the present plant at Youngstown. Both units are for 25-cycle, 3-phase currents, 6600 volts, one to operate condensing and the other non-condensing, with steam pressure of 150 pounds per square inch. The exhaust from the non-condensing turbine will be utilized for heating boiler feed-water in an open-type heater.

The Northern Specialty Company, 63 Columbia street, Utica, N. Y., has installed the Northern self-closing safety water gages on the boilers in fifty manufacturing and heating plants in Hartford, Conn. They have been placed on the boilers in the school buildings, Trinity college, county buildings, hospitals, asylums, Aetna Life building and other insurance buildings, and the balance on the large manufacturing plants there. The new illustrated catalog, No. 3, just issued, will be mailed upon request, also the Hartford list of users.

The new power stations of the North Shore Electric Company, at Waukegan and Blue Island, near Chicago, are furnished with alternating-current electric Northern cranes, furnished by the Northern Engineering Works, of Detroit, Mich. These cranes are of 30 and 25 tons capacity, respectively, of 58 and 39-foot span. The larger crane is equipped with an auxiliary high-speed alternating-current hoist. The Black Hills Traction Company has recently installed an 8-ton 32-foot span Northern traveling crane at Spearfish, South Dakota.

The Loomis-Pettibone Company announces its recent incorporation. The new company will be exclusively engaged as consulting en-

gineer. It intends adhering to the work with which the members have been identified during the last twenty years and will continue to specialize in the design, construction and operation of power, fuel and illuminating-gas plants, and their application to industrial, mining, municipal and central power-station work. The company is thoroughly equipped for investigations, tests and reports. The principals in the new company are Burdett Loomis, Hawley Pettibone, H. A. Kimber and C. Lee Straub.

Walter B. Snow has opened an office at 170 Summer street, Boston, Mass., and announces that he is prepared to undertake work of any kind in the field of publicity for manufacturers of machinery and allied products. His regular service will cover the conduct, on a salary basis, of the publicity departments of a limited number of non-competitive clients. Special service will be rendered to others in the form of general advertising, catalog making, technical writing and investigation. The intimate acquaintance with engineering in general, and publicity in particular, acquired during nearly 25 years' connection with the B. F. Sturtevant Company, encourages him in the belief that this service can be made of exceptional value.

A recent issue of the *Boston Journal* contains a reproduction of an advertisement printed for the American Steam Gauge Company more than fifty years ago. In 1851 at the Crystal Exposition in London there was exhibited an improved steam gage, patented and owned by M. Bourdon, of Paris. The American rights to manufacture this gage for one year, with the privilege of purchasing, was secured by a Boston company. At the expiration of the year the American rights were purchased by George H. Fox, who associated with him H. K. Moore, an expert machinist, and others, and from that date the success of the Bourdon tube was assured in the United States. In 1854 Mr. Fox purchased from his associates their entire interest and rights to manufacture, and organized the American Steam Gauge Company, which in 1900 became the American Steam Gauge and Valve Manufacturing Company.

Help Wanted

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

WANTED—Salesmen on commission for high-grade power specialties. Address stating experience. Chas. T. Luce Co., 160 Congress St., Boston, Mass.

WANTED IMMEDIATELY—A stationary engineer for cement plant in middle west; 2400 h.p. steam engines and 1200 kw. alternating generators. Apply at once, Box 278, POWER.

WANTED—A man with experience in the sale of engines and engine specialties, preferably one that has had shop experience and understands how to indicate engines, set valves, etc.; for further information address Box F, Hudson, N. Y.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

DRAFTSMAN, university graduate, married; 28 years old, with 5 years' experience in steam-turbines, boilers, governors and water turbines, wishes position. Box 283, POWER.

WANTED—A position as foreman in western Connecticut; Bridgeport or vicinity preferred; experienced with all modern furnaces. Dwight Hollister, 72 Beardsley St., Bridgeport, Conn.

TURBINE ERECTING ENGINEER, formerly chief engineer central station desires permanent position; married, total abstainer, owns tools and indicator; best references; salary moderate. Box 291, POWER.

CHIEF OPERATING ENGINEER capable of designing, installing and operating economically large industrial, electrical, refrigerating, and water works plants, desires to connect with a first-class concern; age 39. Address Box 294, POWER.

MINING ENGINEER with extensive acquaintance among western mining men would accept position as traveling sales agent for first-class machinery house, mining machinery preferred; only those wanting first-class man at good salary need answer. Address Box 288, POWER.

WANTED—Position by erecting engineer who has had several years of practical erecting experience in reinforced concrete, mill building and power house construction work and can furnish first-class references from leading firms as to ability in these lines; location immaterial. Address Box 289, POWER.

POSITION WANTED as chief engineer or superintendent of power plant; familiar with power, lighting and railway systems; thoroughly experienced with water power; reciprocating and turbine engines, also with various types of water tube boilers; am a capable man with best of reference. Box 287, POWER.

WANTED—Position by a licensed steam engineer and electrician of eight years' experience; fully understand business from coal bin to superintendent's office; A-1 and State references; also from largest electrical company in United States; married; 30 years old; a teetotaler. Address Fred L. James, Goodland, Ind.

WANTED—Position as sales manager or purchasing agent, with chance to gradually secure interest in the business; 10 years' experience in manufacturing and sale of steam and gasolene engines, steam and power pumps, electrical machinery, etc., including shop and drafting room experience; was salesman for several well known concerns, and later sales manager for large machinery and supply house; young man; technical graduate; desire to locate where a knowledge of engineering and commercial practice, Yankee sense, and business diplomacy can be used to best advantage. Address Box 292, POWER.

Miscellaneous

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

IF YOU DESIRE to learn the latest improvement in steam boilers, correspond with the Detroit Water Tube Boiler Co. See their advertisements on page 170.

ENGINES AND BOILERS, ⅛ to 2 h.p. engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make free examination and report if patent can be had, and exact cost.

WE FURNISH engines for low pressure and high pressure, slow speed and high speed, adapted for all purposes. Send for circular and prices. Greenfield Steam Engine Wks., Harrison, N. J.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

For Sale

Advertisements under this head are inserted for 50 cents per line. About six works make a line.

FOR SALE—One 16x26x42 Allis Corliss, tandem, compound engine, first-class condition. Morehead Mfg. Co., Detroit, Mich.

FOR SALE—2400 lbs. of 1⅝" new Manila transmission rope in two lengths; price 9c. per lb. Address P. O. Box 595, Harrisburg, Pa.

FOR SALE—One 13"x18", 125 h.p. automatic Erie City four valve engine; two 50 h.p. Olds gasolene engines; can be seen in operation. Carl E. Schmidt & Co., foot of Lieb street, Detroit, Mich.

FOR SALE—Cyclopedia of electricity; five volumes, three-quarters red morocco, leather binding; books are in fine condition; used but short time; cost $19; will sell for $9. Address "R. S. M.," Box 425, Chicago, Ill.

FOR SALE—A slightly used engineering library. Steam, electrical, mechanical. Twelve volumes bound in three quarters red morocco leather. Cost new, $60. Will sell for $18. Address "R. L. N.," Box 425, Chicago, Ill.

FOR SALE—Cyclopedia of engineering; steam, electrical, mechanical; bound in three quarters morocco; five volumes; cost new, $19; are in fine condition; will sell for $9. Address "M. B. T.," Box 425, Chicago, Ill.

FOR SALE—One "Ideal" engine 75 h.p.; one 60 kw. Warren alternator, 2200 volts 60 cycle, single phase, complete with exciter; guaranteed first-class condition, belted. Address Dept. of Public Utilities, City of Iola, Kansas.

Will sell cheap, new dismantled four-cycle vertical gas engine rated at 800 I.H.P. on producer gas and built by Struthers-Wells Co.; will give no guarantees as engine did not run to our satisfaction on this kind of gas. "H. M. C.," POWER.

FOR SALE—1 35 H.P. General Electric motor 500 volt D.C.; 1 20 H.P. General Electric motor 500 volt D.C.; motors are in first-class condition and were taken out solely on account of change in voltage of our power supply; have been run only a few months. Address "K. V.," Box 290, POWER.

FOR SALE—500 kw. d.c. railway generator, belt driven, three bearing, e.m.f. 550, six pole, 320 r.p.m., serial number 149054, manufactured by the Westinghouse Electric and Manufacturing Company; machine in good condition. For further information, address Detroit United Railway, Detroit, Mich.

FOR SALE—One Hall steam air pump, direct double acting, steam cylinders diameter 12", air cylinder 16", stroke 14", steam supply 2", steam exhaust 2½", air inlet 5", air outlet 4". To be run at 125 revolutions per minute; the horse power required to operate about 55; capacity of compressor about 400 cu.ft. free air per minute, at 40 pounds terminal pressure. Box 293, POWER.

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Practical Side of Steam-turbine Operation

An Engineer Tells what He Has Learned about Turbines during Three Years' Experience with Them in a Large Central Station

BY W. J. KENNEDY

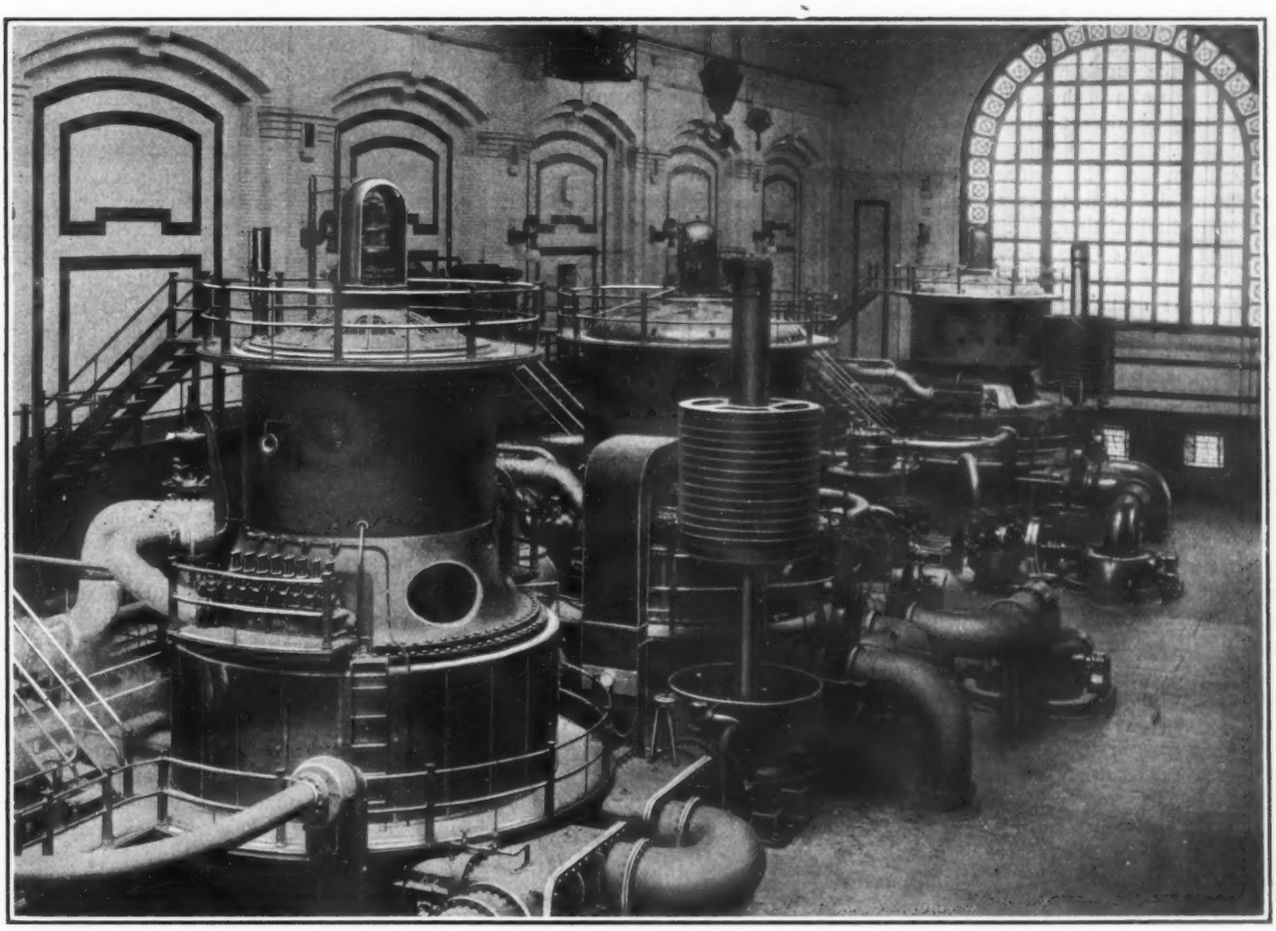
Nearly three years ago two 5000-kilowatt Curtis steam turbines were installed in the Boston Edison Company's L-street station at South Boston, Mass., and have been in continuous operation since that time. With the introduction of the turbines and certain of their auxiliaries came engineering features new to the plant and the operators, and the practical experience thus afforded the operating force, of which the writer is one, forms the basis of this article.

By way of preface, it may be stated that in this plant especial attention has been given to the labor organization, with a view to getting the best results with the least friction, and the methods adopted to regulate matters of authority, discipline and duty have been worked out very satisfactorily. The engine and turbine stations being operated as one system necessitates the employment of operators whose capabilities are necessarily interchangeable, in order to insure flexibility.

The Equipment and Order of Operation

As is well known, the turbines are of the vertical type, with surface condensers in the bases. The installation is on the unit plan throughout, each unit having five auxiliaries—circulating, step-bearing, wet- and dry-vacuum and feed-pumps. The accumulator is not included, as it is part of the step pump and bearing. All of this apparatus is steam-driven with one exception, the wet-vacuum pump, which is motor-driven. When starting up a turbine these units should be put on the system in the order named, if possible, and they should be shut down in the reverse order; the only exception to this general rule being when an unusual condition arises to vary it. Such a system not only gives each man a complete knowledge of his regular duties, but has a tendency to eliminate delays and confusion.

The general arrangement of the auxiliaries has been with a view to operating convenience, with the result that practically all the apparatus are located on one floor. This also reduces the operating force required to a minimum. The full advantage of such an arrangement, however, is best appreciated by the operator, as he can give better attention to apparatus which is in full view all the time.



THREE 5000-KILOWATT CURTIS STEAM TURBINES IN BOSTON EDISON COMPANY'S L-STREET STATION

Preparing to Start a Unit

When getting a steam turbine ready to

put in service the operator will follow the same general practice that he would with a reciprocating engine. Before turning on the steam for warming up the turbine, circulation must be established in the condenser, otherwise the condenser will become overheated, and this will have a bad effect on the condenser shell, tube packings and joints, due to extreme ranges in temperature. Also, it will make priming more difficult, on account of vapor accumulating in the circulating side of the system.

The air exhauster, or steam siphon, is used for the purpose of priming, being connected to the suction line of the circulating pump. While the air is being removed the circulating engine should be started and all ready for work when the pump has been primed. This pump being of the low-speed centrifugal "volute" type, it will not expel the air, therefore, an exhauster, or some other pumping arrangement, must be employed.

The pump which furnishes lubrication for the step-bearing should be started next, and the supply valve to the bearing opened; this allows the accumulator to be worked up to the running position and maintained there. The importance of the accumulator must be realized, it being a storage of lubrication for the step-bearing, for a limited time, in case of trouble with the pump on this service. Experience has shown that it is good practice to have the accumulator charged, when shutting down, having first cut it off the line, thereby preventing the displacement of its supply. Then, when an emergency start is necessary, the step service can be put on and cared for by the accumulator until the pump can be started.

As soon as lubrication has been turned on the step-bearing, so that the turbine is free to turn, the automatic stop-valve in the steam line, between the throttle and the turbine, should be opened and set, particular care being taken to do it properly; all its mechanisms should have perfect engagement. When this has been done the turbine is ready for steam for warming up. The steam is admitted through a special bypass at the throttle to three of the thirty admission valves on the turbine, these valves being separately and electrically controlled, not only for the purpose of better regulating the amount of steam admitted for warming up, but also for better control of increasing the speed, which takes from one to five minutes according to conditions.

The wet- and dry-vacuum pumps come next, and of these the former should be started first, to remove any water which may have accumulated in the condenser after shutting down the previous run. This might exist from several causes, one being the step-bearing lubrication, as water is used for this service and is discharged to the condenser. Or, there might be throttle leakage or leakage past the check-valve on the wet-pump discharge. When the water has been reduced to a safe level, the dry pump should be started, and it has been found to be advisable to start these units in this order, especially where the dry-pump suction is located near the bottom of the condenser, as there is liability of large quantities of water going over which might result in the failure of some of the pump parts. This type of pump is not intended to handle water, having a greatly reduced piston-clearance and a slide valve, with a Meyer cut-off on a balance plate.

Operative Features to be Watched

During the early period of raising the speed, the exciting set should be started and the excitation given to the field. It is well to observe carefully the different conditions of the operating mechanism from the time of starting until the turbine is on the system, it having to pass through a great range of speed in a short time, especially in emergencies. If the conditions are not normal, it should be discovered at once. The operation of the governor and the electrical control, as well as the valve movements, should be noted, and the valve-casing drains and the pilot-valve exhaust taken care of in their order, to insure free operation.

An important feature of the wet pump which should be considered is that it should not be run without a partial supply of water. This is necessary as a lubricant, to prevent heating and undue wear of the internal parts, especially if it should be of the high-speed single or multiple-stage centrifugal type, and not properly balanced for the varying pressures of intake and discharge. The probable cause of such a pump not removing all the condensation from the condenser under normal conditions would be an air-leak around the packings on the impeller shaft, or in the connections between the pump and the condenser. Either would prevent a free flow of the column of water to the pump and result in a gradual accumulation in the condenser. An abnormal back pressure on this pump would introduce a similar condition also. It is desirable to have a glass suitably located on the condenser, with sufficient range to show if the condensed steam is not being removed as fast as condensation is taking place.

How to Preserve Running Balance

Careful attention should be given to any change in balance, and its causes learned, if possible. It has generally followed that when units are put in service if they are not properly synchronized a poor balance will result. Cases have been noted where true alinement and a fine running balance have been destroyed by lack of care on the part of the operating force. Therefore, particular attention should be given this part of turbine operation. When a turbine is being put on the system the operator should never synchronize when speed is falling off, that is, changing to a lagging speed from the rest of the system, but it should be phased, when accelerating, to the speed of the other units. This method will entirely eliminate severe shocks, preserve the balance and maintain the adjustment of parts.

Contrary to the opinions of many, with regard to the step-bearing, no troubles are met with after final adjustments are made, and its successful service depends entirely upon a liberal and continuous supply of lubrication. Water is being used successfully on all step-bearings in this plant, and is regulated automatically by the baffler, which is a fluid-friction device easily adjusted for any desired pressure drop. The purpose is to give each step its required amount of lubricant regardless of its size. After this has been properly set it does not have to be changed, for with this type of turbine there is no change in step pressure, as they operate without thrust, with reference to steam pressure and loads.

Should any change be made in the adjustment of the moving elements, which would materially change the clearance and cause rubbing, an arrangement is provided at the step-bearing for re-adjusting while the unit is in service. The direction in which the clearance is to be changed, and the amount, may be determined by clearance indicators attached to each stage of the machine. This is a simple operation, as the clearance between the moving and stationary parts is a matter of indifference, and has a large practical range through which it may be moved if necessary.

The running position should be taken occasionally to know if there is wear going on. Should the water lubricant at the step-bearing contain quantities of solids which might pass the strainers, then a gradual wearing away of the step-bearing blocks might occur. This, of course, would change the clearance slightly, but in so doing would extend over quite a length of time. An imperfect balance would have the same effect on step- and guide-bearings and the wear would be much more rapid. Therefore, it is highly necessary that a good balance and alinement should always be maintained.

Treatment of the Accumulator

Reference has been made to the accumulator and the method of handling it. It should be tested daily to insure its operation; it should have a predetermined stroke, regulated by a counterweight actuated by means of a cord or levers connected to a balanced governing valve on the pump. With such an arrangement variations will be kept within a range of two inches, and the stroke will thus require very little personal attention. It is possible, even on large sizes, heavily weighted, to pack them too tightly, so that sufficient friction may exist to over-

come the difference in pressure (from 400 to 500 pounds) between the pump and the step-bearing. In such case, should the pump be stopped, the accumulator would not furnish lubricant at the required pressure. Care should be exercised when using fibrous packings on this work that particles do not enter the line and foul the strainers, or it will reduce the supply. The strainers should be removed frequently, and the settling chamber in the baffler opened and flushed. The top and middle bearings on these turbines are oiled from a distributing reservoir located on the top of each machine. It has been found that these bearings require no especial attention, beyond the same care as would be given to an ordinary motor bearing. However, a free flow of oil through the bearings is afforded, as being desirable for cushioning.

When shutting down, the turbine is throttled and cut off the system when the load is down to about 200 kilowatts. The automatic stop-valve should be tested frequently. This is done by allowing the machine to speed up to the point at which the emergency weights are set, and when they are thrown out the latch mechanism is knocked off and this releases the valve, which closes instantly.

During the shut-down period cleaning should be done and a careful inspection made. All positive and automatic apparatus should be tested to insure the freedom of the parts from sticking.

Where electrically controlled valves are used they should have careful attention and be kept in the best condition possible to insure perfect regulation. Experience has demonstrated that on account of the absence of reciprocating parts, the engine-room force is too apt to neglect some of the less important features in turbine work, but it should be remembered that a certain amount of skill is required to operate steam turbines, and that the "fool-proof" engine has not yet been designed.

An Early Suggestion for Indirect Governing

The accompanying engraving, Fig. 1, is a reproduction of a sketch made by John F. Allen (of Porter-Allen engine fame), in 1880, and now in the possession of Franklin Phillips, of the Hewes & Phillips Iron Works. It was a suggestion for the mode of indirect governing, since quite frequently used upon large steam engines. The falling of the governor ball *A* raised the valve *B* and admitted fluid pressure to a piston in the cylinder *C*. The downward movement of the piston raised the link-block, gave the valve greater travel and at the same time reclosed the pilot valve *B*. With the hydraulic control the Porter pendulum governor performed merely the office of indicating changes of speed which were immediately taken up by the movement of the hydraulic piston, when the governor in all cases returned to its normal plane of flotation. If still further demands were made upon it the operation would be repeated. The same principle is now in common use upon damper regulators, etc., but this early suggestion of it as applied to a steam-engine governor is interesting from an historical point of view.

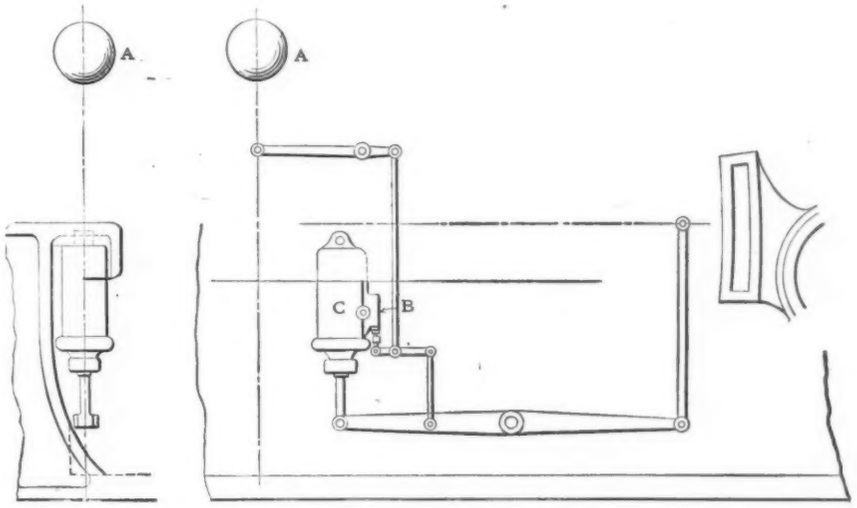


FIG. 1. EARLY SUGGESTION FOR INDIRECT GOVERNING

A device embodying these principles was created and used by Mr. Allen many years before, on the engines which operated Burr's hat-forming mill in Jacob street, New York City ("down in the swamp"), where it gave perfect control of a pair of beam engines built by Thurston & Gardner (later the Providence Steam Engine Works). A governing device involving almost the identical details of Mr. Allen's appliance on the old beam engines is now in use on the horizontal-vertical engines in a large power house in New York City.

Fig. 2 shows the application of the direct method as formerly used.

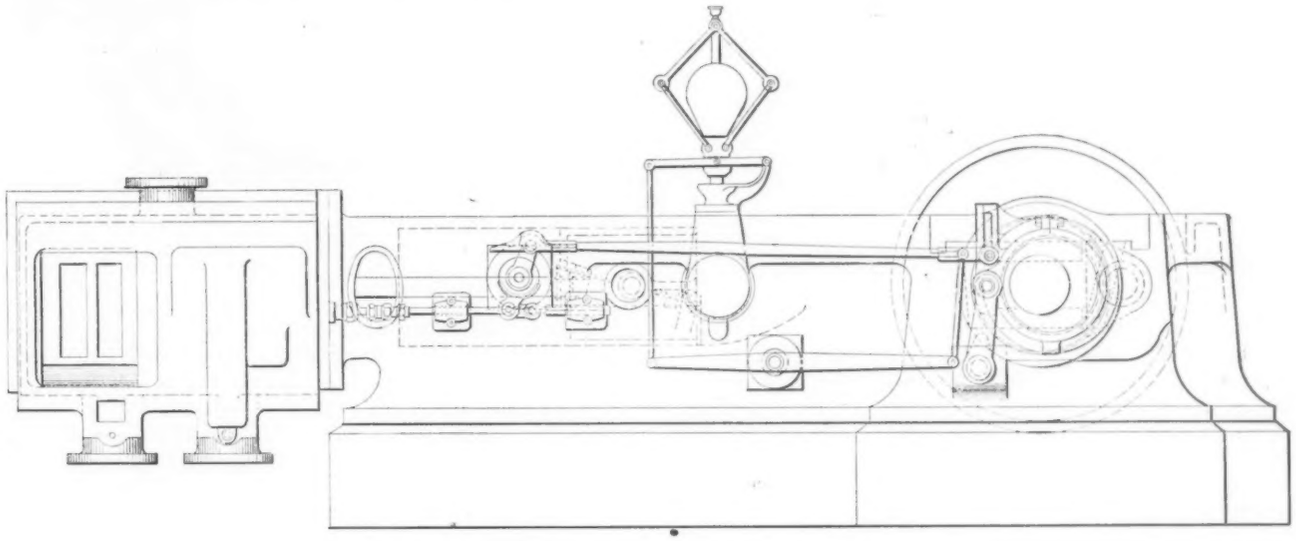


FIG. 2. SHOWING THE DIRECT METHOD AS FORMERLY USED

Salient Principles of Roller Bearings

Practical Differences between Straight and Tapered Types; Need of Separation of Rollers and How Best to Accomplish It

BY J. F. SPRINGER

The roller bearing is, perhaps, the most ancient type of anti-friction device. The use of round pieces, of wood or other material, to enable men to move weights over the ground is such a natural process, and so easily resorted to, that it is by no means a bold assumption that they were used in prehistoric times, by men who lived and worked before the flood. Indeed, it is quite likely that Noah and his sons resorted to such means to move the bulky timbers which entered into the construction of the Ark, from the forest to the place where the craft was built. Probably the builders of the Pyramids not only employed rollers to transport the huge blocks of stone from the quarry, but continued to use them in the process of mounting one course of masonry upon another. For if, as some have supposed, a temporary earth bank was constructed to the top of each course of masonry laid and the blocks for the next higher course were transported over the inclined surface of this embankment, we may well imagine that rollers were resorted to in the solution of this final transportation problem. At all events, no man can say when rollers were first used —nor can he even approximate the time. It is doubtful, too, whether it can be asserted with any degree of confidence just when or where plain cylindrical rollers, of the same general type as those assumed to belong to prehistoric times, were first assembled in continuous sequence between two circular raceways. It was a long step in advance, however, for this expedient was the forerunner of the application of such bearings to wheels and other revolving bodies in which the automatic replacement of rollers under the load is a prime essential. This, then, is the prototype of the modern anti-friction roller bearing.

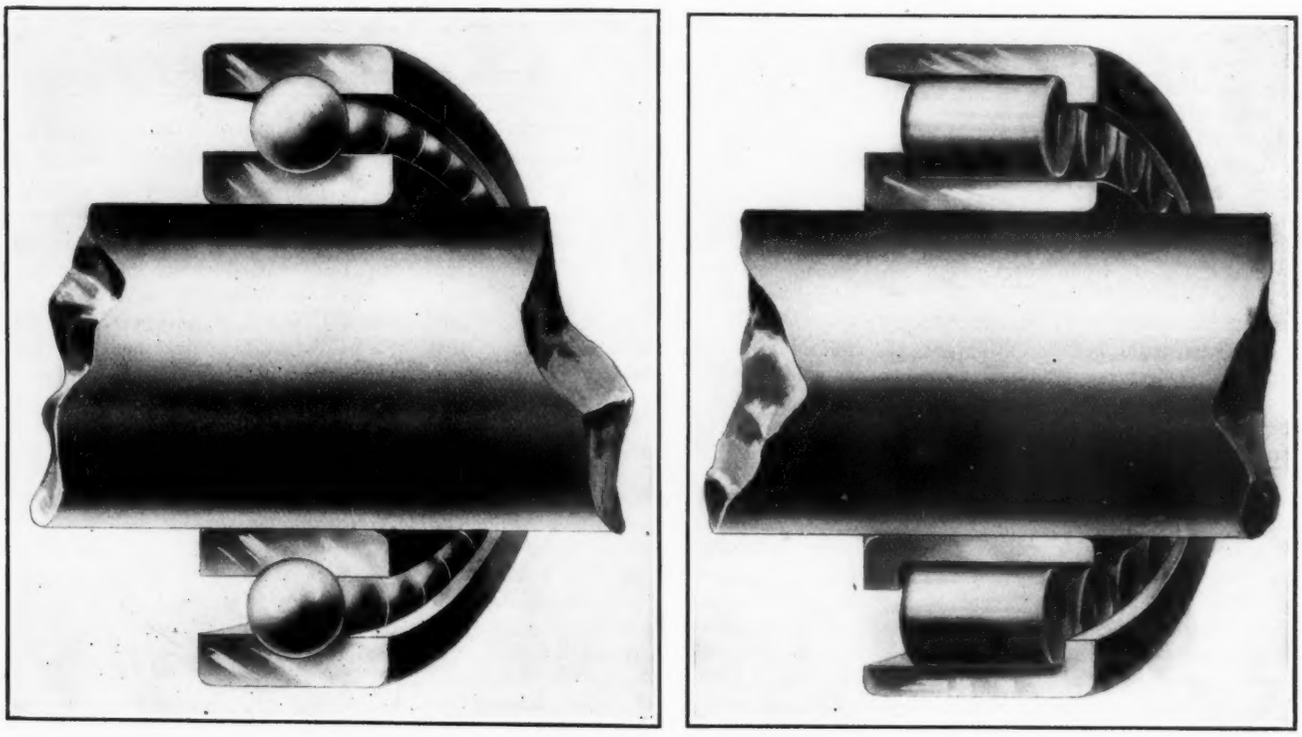


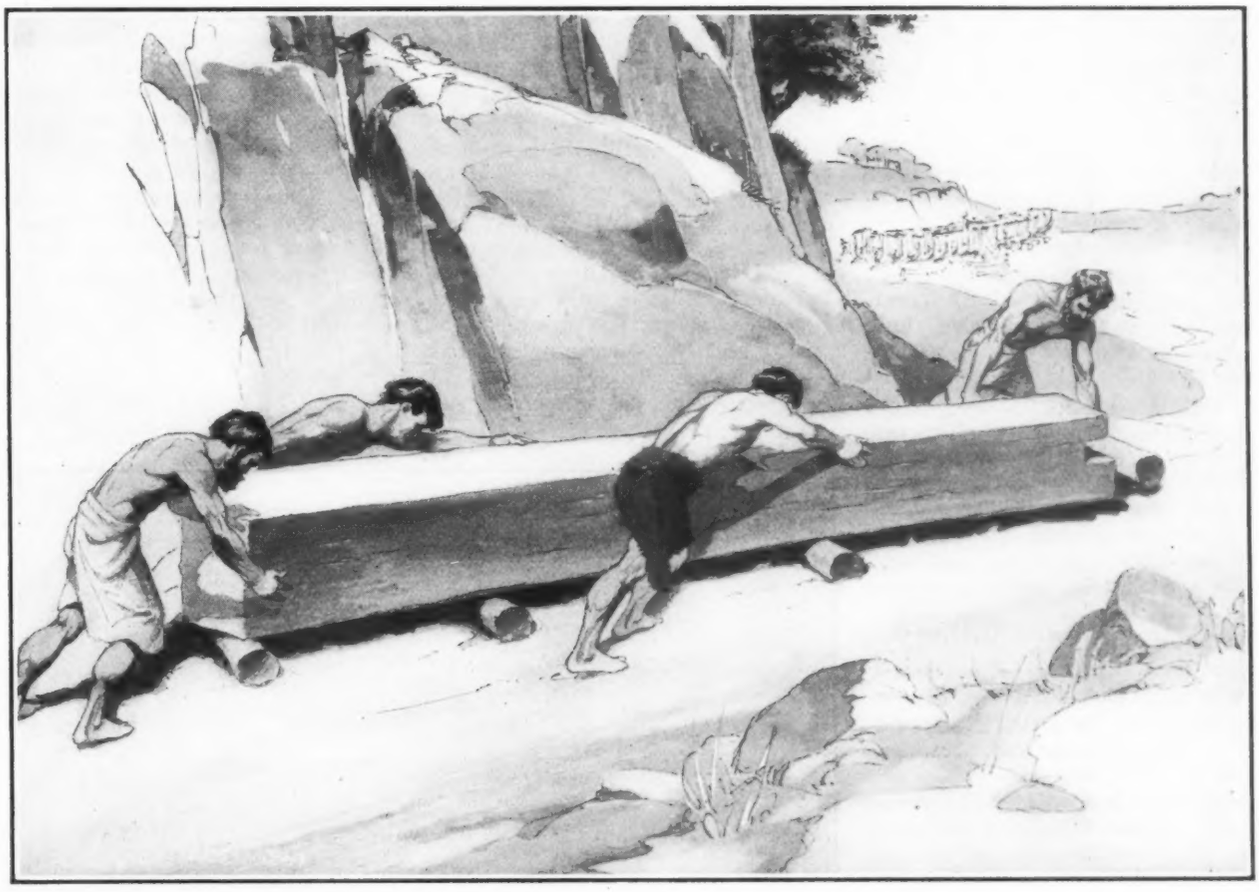
FIG. I. COMPARISON OF BALL AND ROLLER BEARINGS

From the foregoing it may be surmised that roller bearings antedate ball bearings. The classification at the United States Patent Office would seem to confirm this view, for by it balls are regarded as a species of rollers, that is, as rollers with rounded ends and having no intermediate length.

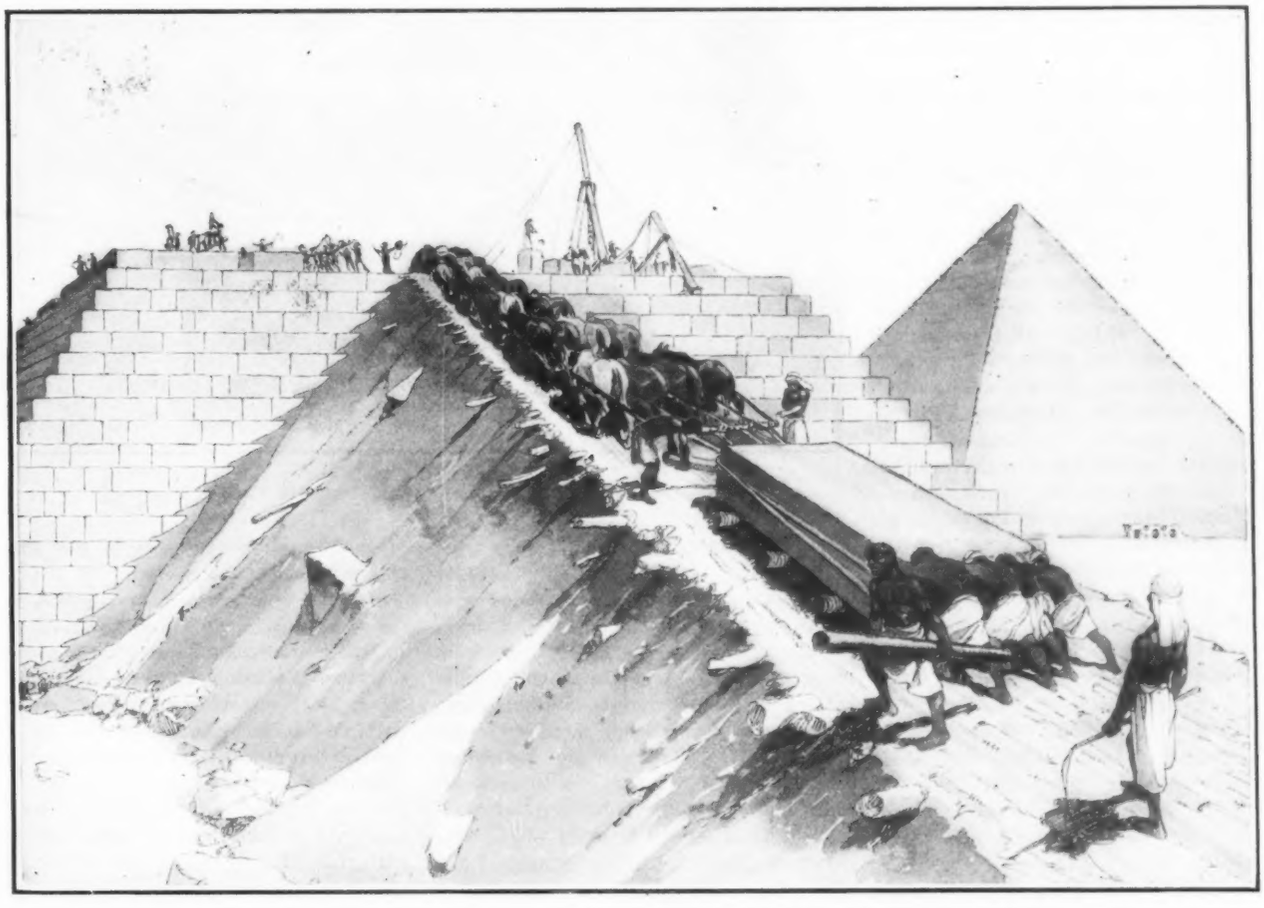
As Compared with Ball Bearings

In comparing ball and roller bearings, the most salient point of difference, perhaps, is that relating to contact with the raceways. Balls practically make point contacts only, whereas rollers contact along straight lines. This is certainly a most striking difference. At the utmost a ball has four points of contact with its raceways, while a straight roller has continuous contact throughout the length of two straight lines, and a tapered roller not only makes contact along two lines but at one or two points in addition. This disparity is enormous. From this circumstance it follows that the roller is not only a better load supporter, but an *immensely* better one. It is quite true that the spherical form of bearing is probably the least destructible of all forms; but this only goes a small distance toward bridging the gulf. It is to be assumed as well nigh axiomatic, in the writer's opinion, that the roller is incomparably the better load supporter.

Of course, where size does not play any part, a ball can be made large enough to equal in load supporting capacity any given roller. But ordinarily size *does* enter, and this being assumed, it must be granted that, other things being equal, the roller is by far the better of the two with reference to sustaining a load.



PRIMITIVE TYPE OF ROLLER BEARING SUCH AS ARK BUILDERS MIGHT HAVE USED



HOW ROLLER BEARINGS MAY HAVE ENTERED INTO THE BUILDING OF THE PYRAMIDS

Another marked difference between rollers and balls is the fact that however a ball may be twisted or turned, its effectiveness as a bearing is ever the same, whereas but one or two displacements are possible with a roller without altering its functions. Thus, in Fig. 1, if a ball be turned in any conceivable direction, it is still in just as adequate a position to act as before. But the slightest movement of one end of a roller in advance of the other alters the conditions in a marker manner.

There are many cases in which load capacity and restriction of size radially do not have to be reckoned with, and in such cases the ball bearing may legitimately compete with the roller bearing, not infrequently with the advantage on the side of the ball bearing. If, however, great sustaining capacity with radial restriction are essential, as is often the case in the construction of heavy machinery, then the roller bearing should be chosen.

Two Types of Roller Bearing

Roller bearings proper, i.e., as contradistinguished from ball bearings, may be divided into two great classes: straight roller bearings and tapered roller bearings. The straight roller bearing is one in which the roller is a cylinder. Its diameter is the same throughout its entire length. Such a roller, together with its companions, rolls between cylindrical raceways, co-axial with the shaft. The axes of the two cylindrical raceways are theoretically coincident, although as a matter of fact a slight deviation from coincidence occurs under load conditions, arising from compression of parts. The axes of the rollers are perpetually parallel with each other and with the coincident axes of the raceways. Ordinarily the rollers are maintained in this position of parallelism with the shaft by means of an alining device called a roller cage.

A tapered roller bearing is one in which each roller is conical, and rolls both within and upon sleeves having conical surfaces in contact with it. All these conical surfaces—three in number—are right cones, or, as they are sometimes termed, cones of revolution. Theoretically, the conical raceways have coincident axes; although in practice, as with straight roller bearings, there is a slight separation of axes due to compression. It is of course necessary for the vertex of each raceway to lie upon the axis of the shaft, and the axis of a roller describes a right conical surface whose vertex also lies upon the axis of the shaft. In order to preserve true rolling of the roller between its raceways, it is important that all these conical surfaces have a common vertex. As with straight roller bearings, it is ordinary practice to maintain alinement, that is, the correct position of the axis of a tapered roller, by means of a cage. Mathematically considered, the cylindrical roller bearing is a species of the conical roller bearing, since by removing the point of coincidence of the shaft axis with the common vertex of the three conical surfaces (the outer raceway, the inner raceway and the rollers themselves) to an infinite distance, the cylindrical roller bearing is evolved.

Differences between Straight and Tapered Rollers

There is a marked difference in practice, however, between these two types. The straight roller is not subject to individual end thrust; that is, when under a radial load the straight roller is not pressed longitudinally in either direction. The tapered roller, on the contrary, suffers an individual end thrust arising from a radial load on the bearing. In other words, it is not an end thrust due to a longitudinal thrust of the housing upon the shaft, or *vice versa*, but it arises from the imposition of a pure-and-simple journal load. In the straight roller bearing, therefore, it is sufficient merely to provide means to take care of any slight tendency of the rollers to slip longitudinally; but in the tapered roller bearing there exists not only a slight tendency to slip out, but these individual end thrusts must be seriously provided for.

Typical bearings of both classes are shown in Figs. 2 and 3. The arrows on the tapered rollers, Fig. 3, show the directions taken by the end thrusts, the shocks of which are absorbed by the ribs *A A*. The roller cage in each instance consists of two annular bands in which the trunnions on the rollers are journaled. These bands are secured in their relative positions by means of long rivets which pass from one to the other between the rollers. From Fig. 2 it will readily be seen that not only is there no individual end thrust of the straight rollers, but that the bearing itself is not as a whole well adapted to receive an end thrust. A longitudinal movement of the housing, relatively to the shaft, will be poorly taken care of by the bearing. This is ordinary practice. In the tapered roller bearing, however, besides the individual end thrust of the rollers, it is possible for the bearing itself to sustain a thrust between the shaft and housing. Incidentally, it should be observed that the straight roller bearing must be exact as to size, as there is no possibility of adjustment if the dimensions of outer and inner sleeves, together with that of the rollers, are not in precise correspondence. In the tapered roller bearing slight variations are permis-

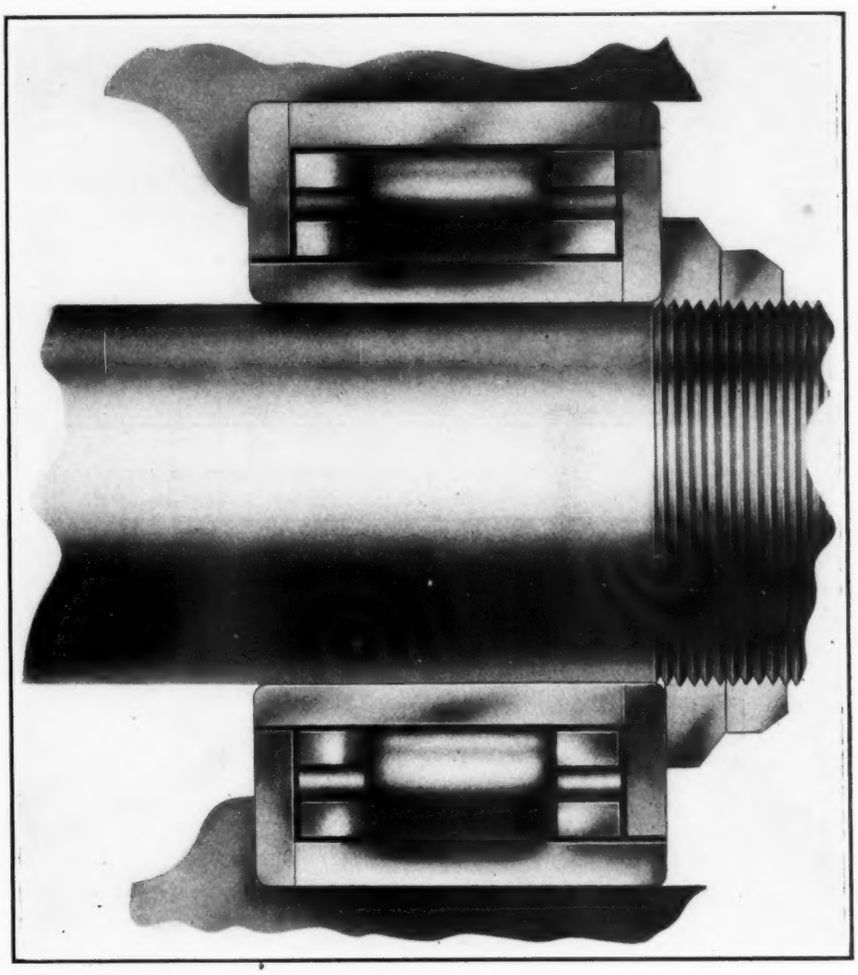


FIG. 2. TYPICAL STRAIGHT-ROLLER BEARING

sible, as adjustment of the outer and inner sleeves longitudinally will readily compensate for a slight deviation from the standard.* The tapered bearing is admirably adapted to sustain the end thrust between shaft and housing, and this in addition to its other good qualities renders this bearing one of the most important types of anti-friction devices.

Alinement of Rollers

In discussing the differences between ball and roller bearings, reference was made to the alinement of rollers. There can be no doubt that anything more than a very slight effort of the rollers to break away from their alinement will lead to serious complications. A consideration

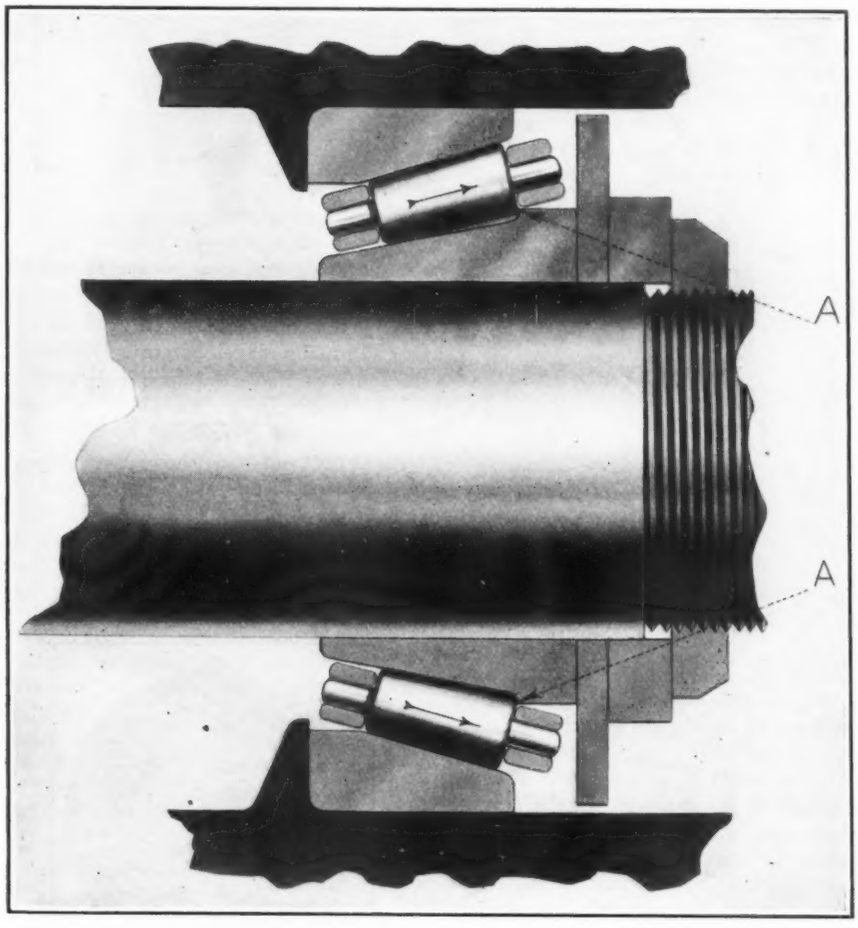


FIG. 3. TYPICAL TAPERED-ROLLER BEARING

of the form of the space between the raceways will soon convince one that the easiest position for a roller to occupy is the correct one. There is no doubt of this fact. But this circumstance alone is insufficient to maintain effectively the correct position of the roller, for the reason that while the correct position is the easiest, the change in the form of the space between the raceways as departure is made from this correct position occurs so gradually that no great pressure is required to force one end of a roller away from correct alinement. This slewing, once begun, would have a tendency to increase, as the pressure or tendency which originates the slewing is apt to force the roller between the raceways until it occupies a position where an excessive share of the load will fall on the deviating end. The movement of this end would be accelerated, with reference to the portion not under such pressure, and so give rise to a pronounced tendency to slew. The result would be serious, with few or no conditions present tending to correction. If this is correct—as far as it goes—no roller bearing (with a few unimportant exceptions where the conditions as to speed and load are so mild that no problem is presented) should be designed without a cage or other device for maintaining alinement. This device should be such as to afford a sharp corrective whenever slewing *begins*.

Some readers may doubt the existence of any tendency to slewing in a properly constructed and adjusted roller bearing, but there is no doubt that unavoidable inaccuracies in grinding and inequalities in hardness of different portions of the rollers and raceways, separately or combined, will be sufficient to accomplish slewing. Assuming, however, that all the parts are without variations in hardness, and that the grinding has been done perfectly, the writer holds that, even with these impossibilities realized, slewing would occur, introduced through variations in the delivery of the load to different parts of the roller. This variation in pressure over the length of the roller would, of course, give rise to variations of compression. There would thus arise varying increases of the radial distances of the points of contact between the outer sleeve and the roller, because at the end of the roller undergoing the more severe pressure the raceways would sustain a more pronounced compression than would be set up at the other end of the roller. Therefore, the points of contact of the outer sleeve at this end would be farther from the axis than the points at the opposite end, on account of the differential compression of the outer raceway.

The rate of advancement of a point of contact increases directly with the increase of radial distance from the axis of rotation. Consequently, while the outer sleeve (which is assumed to be the driving member) is moving faster at both ends of the roller than would be the case apart from the compression, the increase is greater at the end supporting the greater pressure. It is possible, of course, that the more severe pressure should be at the butt end of the roller, in the case of a tapered roller bearing, and that the diminishing increase in rate of revolving, as one passes to the smaller end, would be precisely the right amount to impart such increase all along the roller as to cause the whole roller to revolve (not rotate) evenly around the inner sleeve. This is conceivable under conditions so rare that they may be considered negligible. If the greater pressure is at the smaller end, or if the bearing is a straight roller bearing, the conditions, of course, are not fulfilled. In practically all cases, then, differential pressure on the roller gives rise to differential orbital motion of the roller, and this results in a slewing effort on the part of the roller, the results of which can scarcely fail to be disastrous.

There are two methods of controlling the alinement: By means of the roller cage, which conforms to the orbital velocity of the rollers and guides them longitudinally; and by shortening the rollers and controlling the alinement by transverse guides.

Separation of Rollers

It has long been observed that both balls and rollers at the locality of mutual contact are moving in opposite directions. This will readily be seen from Fig. 4, where the outer sleeve is represented as the driving member and the inner one as quiescent. Of course this is a case of sliding friction. Whether it is of especial importance depends upon whether the

*The writer does not wish to be understood to mean that appreciable variations in size between rollers in the same bearing are permissible; that would be sheer nonsense.

pressure between contacting rollers is considerable or not. If, as the writer has demonstrated, it is found to be very considerable, the use of some device for the purpose of securing the elimination of this sliding friction under considerable

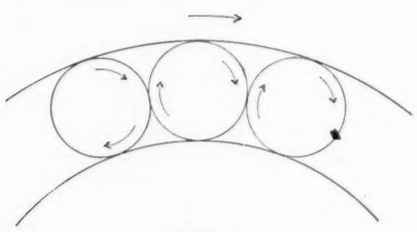


FIG. 4

pressure is imperative. From the standpoint of the elimination of friction, the best method of doing this is to introduce a rolling member between every pair of rolling members. It is important that this separator be freed from any direct participation in the load, for the reason that the separator rotates in a contrary direction at the point contiguous to the driving raceway, so that if a share of the load should be delivered to it by that raceway, the result would be sliding friction under pressure, the very thing it is sought to avoid. This will be understood from Fig. 5. As the separator should be secured in position by some sort of holding device, a radial pressure either out or in would result again in sliding friction under pressure. It is a vital point, then, that the rolling separator should be held in such position as to be under no pressure, whether out or in. There is just one position where these conditions are fulfilled. If the center of the rolling separator is maintained on the straight line joining the centers of the bearing rollers, the only pressure to which the separator will be subject will be the circuit pressure of the adjacent bearing rollers toward each other.

The use of rolling separators in roller bearings has received but a limited amount of application in actual practice. Perhaps this has resulted from the fact that in using various devices to maintain alinement, actual separation is brought about by the alining device itself, or may easily and naturally be secured in connec-

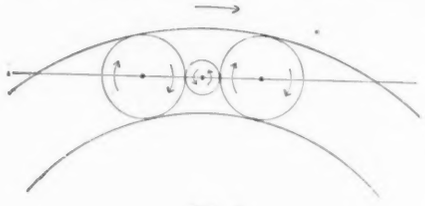


FIG. 5

tion with it. This is the usual practice. The writer is of the opinion that while this sort of separation does not eliminate the sliding under pressure, yet there is some reduction of it. The circuit pressures existent in a full raceway of rollers would appear still to be present in comparable amounts even after separation of the rollers by means of the alinement device, these pressures being now transmitted through its framework.

Assuming, then, that there are still existent circuit pressures in considerable amount, which are exerted between the rotating bearing rollers and the alining device, it will still have to be admitted that the sliding friction under pressure is not quite the same as before separation. The reason for this is that the velocity under which the friction occurs is now largely reduced; for, in Fig. 4, at a point of mutual contact between rollers the surfaces are moving in opposite directions. In Fig. 6 (which is a transverse section through the center of a roller bearing, the alining arm S being non-rotatable), the velocity occurring between a roller and S is one-half that between the contacting rollers in Fig. 4. The *number* of contacts has been increased, however. The writer is of opinion that the reduction in speed more than compensates for the increase in number of frictional contacts. If this is correct, the separation of rollers, even by non-rolling separators, would seem to be attended by some reduction of friction. The load-sustaining

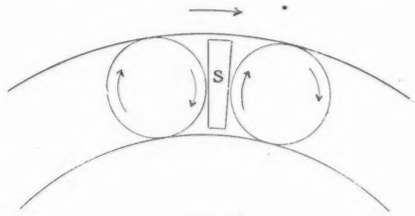


FIG. 6

capacity has to be reduced somewhat on account of the smaller number of bearing rollers. A slight increase in the diameters of the rollers, however, effects such a great increase in load capacity that the disadvantage of slightly reducing the number may be largely disregarded. To recapitulate this last discussion: The use of any kind of separator, whether rolling or non-rolling, would appear to be advantageous in a roller bearing, especially if the non-rolling separator performs alining service in addition. The rolling separator properly used, however, is by far the best means of eliminating circuit pressures.

The American Museum of Safety Devices and Industrial Hygiene is now occupying the entire fifth floor at 231 to 241 West Thirty-ninth street, New York City. The object of the museum is to educate the public to the use of devices and methods tending toward the safety of the public and employees in industrial establishments. Admission is free and space is sold at a price which will merely make the museum self-supporting. Application should be made to Dr. W. H. Tolman, director, at the above address.

Catechism of Electricity—XXIX

Recording Voltmeters and Ammeters

557. *Do recording voltmeters and ammeters operate on the same principles as*

FIG. 145. A RECORDING VOLTMETER

the recording watt-hour meters previously described?

No. Recording voltmeters and ammeters as usually made operate by reason of the action of a solenoid upon a plunger.

558. *Illustrate a recording voltmeter and describe its operation.*

Figs 145 and 146 show, respectively, front and rear views of a common form of recording voltmeter. In Fig. 146 the case has been removed to show the working parts. The solenoid, consisting of two coils of wire, is inclosed at *a a*, and its ef-

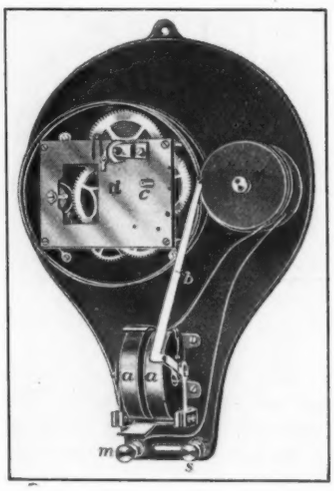


FIG. 146. REAR INTERIOR VIEW OF THE RECORDING VOLTMETER IN FIG. 145

fect depends upon the voltage applied to the terminals m and s of the meter. The resistance coil of the voltmeter is shown at r. The plunger which is actuated by the solenoid has attached to it the pointer b, Fig. 145.

A circular disk is revolved about the

center *c*, with a uniform rate of motion, by means of the clock-work shown at *d*, Fig. 146. On this disk is fastened a paper dial *e*, Fig. 145, on which are printed circles, as at *o*, to indicate the voltage when the pointer *b* is swung outward from the in-

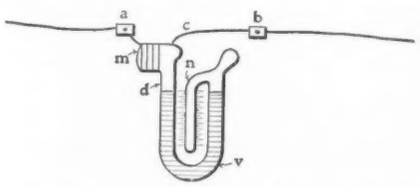


FIG. 147. DIAGRAM OF A MAXIMUM-CURRENT RECORDER

ner circle onto or near one of the other circles. There are also radial lines, as at *n*, extending from the center to the outer rim of the dial, marking the divisions of time, each line representing one hour of the twenty-four and being so designated at the outer extremity. Intervening lighter lines indicate fractions of hours. The end of the pointer *b* is provided with a recording pen, which traces a line on the dial as the latter revolves, and thereby continuously records the voltage on the circuit to which the meter is connected.

559. *What is the difference between recording voltmeters and recording ammeters?*

The solenoid of the ammeter is of heavy wire and connected in series with the circuit instead of in shunt to it.

Maximum-current Recorder

560. *What purpose is served by a maximum-current recorder?*

The maximum-current recorder is employed to determine the greatest strength that the current attains during any given period of time. If used in connection with a recording watt-hour meter it furnishes a basis upon which to reckon the charge for electricity supplied.

561. *Illustrate and describe the operation of a maximum-current recorder.*

The diagram, Fig. 147, illustrates the principle of operation of such a meter. One side of a circuit in which it is desired to determine the maximum use of current

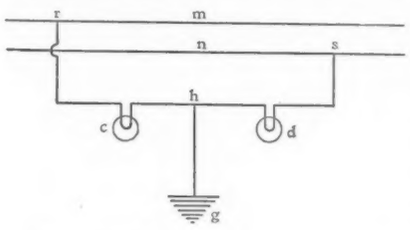


FIG. 148. SIMPLE FORM OF GROUND DETECTOR FOR LOW-POTENTIAL CIRCUITS

is opened and connected to the terminals *a* and *b* of the meter. The wire *c* which connects these terminals passes around the glass bulb *m*, which is hermetically sealed and connected to the glass tube *d* holding a liquid *v*.

The heat developed by the current in the wire *c* expands the air in the bulb *m*, which forces the liquid down in the left-hand column of the glass tube and up in the right-hand column. If the current be sufficiently high, the liquid in the right-hand column will run over into the central tube *n*, where it must remain until the instrument is readjusted. A scale back of the tube *n*, calibrated in amperes and watts, enables the hight of the liquid in the tube *n* to be measured in these terms. If the maximum load lasts 5 minutes, 80 per cent. will register; if 10 minutes, 95 per cent. will register; and if 30 minutes, 100 per cent. will register.

After a reading has thus been taken and recorded for a certain length of time, the liquid is returned to the outer tubes by tipping up the apparatus, which is hinged at the top to permit of this being done.

Ground Detectors

562. *What are ground detectors?*

Instruments or devices for indicating a

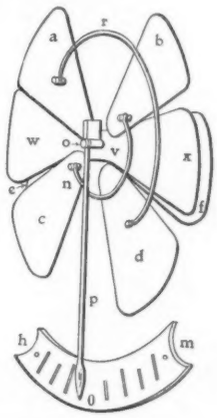


FIG. 149. WORKING PARTS OF A GROUND DETECTOR FOR HIGH-POTENTIAL CIRCUITS

"ground," or accidental connection between the earth and a conductor intended to be insulated from the earth.

563. *Are ground detectors adapted for use on both low- and high-potential circuits?*

Yes; but in the latter case a more complicated device is necessary than in the former one.

564. *Illustrate and describe a ground detector for low-potential circuits.*

A simple low-potential ground detector is shown in Fig. 148. It consists of two incandescent lamps *c* and *d*, each of the voltage of the low-potential circuit *m n*. These lamps are connected in series with each other, and one of the terminals is connected to the main conductor *m* at *r*, while the other terminal is connected to the conductor *n* at *s*. Between the lamps, at *h*, is "tapped" a wire which runs to the ground *g*.

If the difference of potential between the wires *m* and *n* is the same as the rated voltage of each of the lamps, they will each be supplied with half the rated voltage, since they are connected in series, and will show dull red. If, however, the wire *m* becomes grounded, there will be no difference of potential between the points *r* and *h*, and the lamp *c* will be short-circuited and remain dark. And, since the points *r* and *h* are of the same potential and the full voltage of the circuit exists between *m* and *n*, the full volt-

FIG. 150. A FREQUENCY METER

age will be supplied between *s* and *g*, or between *s* and *h*, and the lamp *d* will burn brightly. When the ground is on the wire *n*, the lamp *c* will burn brightly and the lamp *d* will be dark.

565. *Illustrate and describe a ground detector for high-potential circuits.*

Fig. 149 shows the working parts of one of these instruments. A vane *v*, composed of sheet aluminum, is pivoted at the center *o*, and is free to revolve; it is electrically connected with the ground and has attached to it a pointer *p* which indicates the position of the vane. Secondary fixed vanes, shown at *a*, *b*, *c* and *d*, are supported on insulators at a short distance from the back or base of the instrument. The wire *r* connects together *a* and *d*, so that the polarity of the pair will be the same when either vane becomes charged. In like manner, *b* and *c* constitute a pair of equal polarity, being connected by the wire *n*. There are two other vanes *e* and *f*, one behind each end of the vane *v*; they are embedded in the base of the in-

FIG. 151. A POWER-FACTOR METER

strument and are in reality not visible, but are shown here in order that their purpose may be clearly explained. The sheets *e* and *f* are the primary vanes, and are connected one to each side of the circuit leaving the station. These vanes will be charged when there is current on the

line wires, and since they are connected one to each side of the circuit, one vane will be charged negatively when the other one is charged positively. Taking any particular instant when the vane *f* is charged positively, the vane *e* will be charged

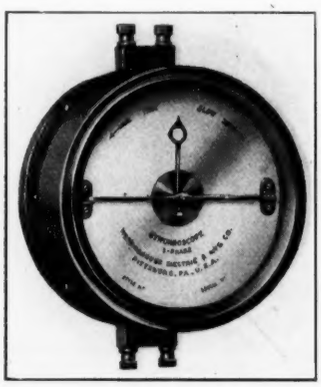


FIG. 152. A SYNCHROSCOPE

negatively. When *f* is charged positively it will induce a negative charge on the vane *d*, and at the same time *e* will induce a positive charge on the vane *c*; *a* being electrically connected to *d*, will also be charged negatively, and *b* will be charged the same as *c*, or positively. At this instant *d* will have a tendency to induce a positive charge in the vane *v* at *x*, but *b* will have an equal tendency to induce a negative charge there, and the action of the two forces will be neutralized. The same reasoning applies to *w*, and the vane *v* will therefore remain in the neutral position between the two pairs of secondary vanes, and the pointer *p* will rest at zero.

If, now, a ground occurs on the line wire with which the vane *f* is connected, the vane *v*, being also grounded, will be electrically connected with *f* and therefore charged positively, or the same as *f*. The vane *b*, however, is also charged positively by induction, and will repel the end *x* of *v*, while *d*, which is negative, will attract it. In the same manner the vane *a* will attract and the vane *c* will repel the end *w* of the vane *v*. Then, since all of the four secondary vanes tend to revolve the movable vane *v* in a clockwise direction, the pointer *p* will move toward *h* on the dial *h m* and will, by its position, indicate roughly the relative conductivity of the ground. When the ground is on the wire connected to the vane *e*, the pointer *p* will move toward *m*, for the polarity of each secondary vane will then be reversed.

The working parts, Fig. 149, are mounted on a marble base and are inclosed and protected from injury by a glass case. The glass case enables all of the parts except the primary vanes to be plainly seen.

Miscellaneous Stationary Indicating Instruments

566. *What other stationary electrical indicating instruments are there in common use in addition to those previously considered?*

There is a frequency meter, Fig. 150, for indicating directly the "frequency" or number of cycles at any moment in an alternating-current circuit. The frequency meter is not influenced by voltage variations, and its scale is generally calibrated from 20 to 30 for 25-cycle circuits and from 45 to 75 for 60-cycle circuits. When used on circuits exceeding 100 volts, a transformer is required.

The power-factor meter, Fig. 151, is another instrument generally used for ascertaining the power factor of an alternating-current circuit. This instrument gives readings which are the ratio of the true watts in the circuit (as indicated by a wattmeter) to the apparent watts (the product of volts and amperes).

The angular position of the pointer at any moment also indicates to the eye the angular difference in phase between current and voltage. The upper half of the dial indicates the power factor for lagging or leading currents when power is being delivered in one direction, and the lower half gives similar indications for power delivered in the opposite direction. In this way the power-factor meter may serve to show a reversal of the direction of power transference. These instruments are made for single-phase, two-phase and three-phase circuits, for 25 to 60 cycles and in sizes up to 2000 volts and 2000 amperes.

The synchroscope, Fig. 152, is used in connection with the parallel operation of alternators to show the amount by which one machine may be out of phase with another and whether it is running too fast or too slow. Its mechanism is similar to that of the power-factor meter, Fig. 151, and is arranged so that the pointer will revolve at a rate equal to the speed difference of the connected machines. By the direction of rotation of the pointer, the synchroscope shows whether an alternator about to be connected in parallel with another already in operation is running too fast or too slow. If the speeds are the same, the pointer will show the angle of difference in phase between the machines, and when the machines are in phase the pointer will coincide with a dummy pointer painted on the disk of the instrument.

A Turbo-electric Battery-charging Plant

A rather unusual type of power plant was recently installed at the main station of the Philadelphia Auto Transit Company, for supplying charging current to the storage batteries of sight-seeing motor omnibuses. The charging voltage ranges from 90 to 110 volts, the lower potential being applied at the beginning of a charge and the voltage being increased as the charging proceeds. No dead resistances are employed in the charging circuits; the generators are built to give any desired electromotive force from 90 to 115 volts, according to the field strength, which is adjusted in the usual way by means of a rheostat.

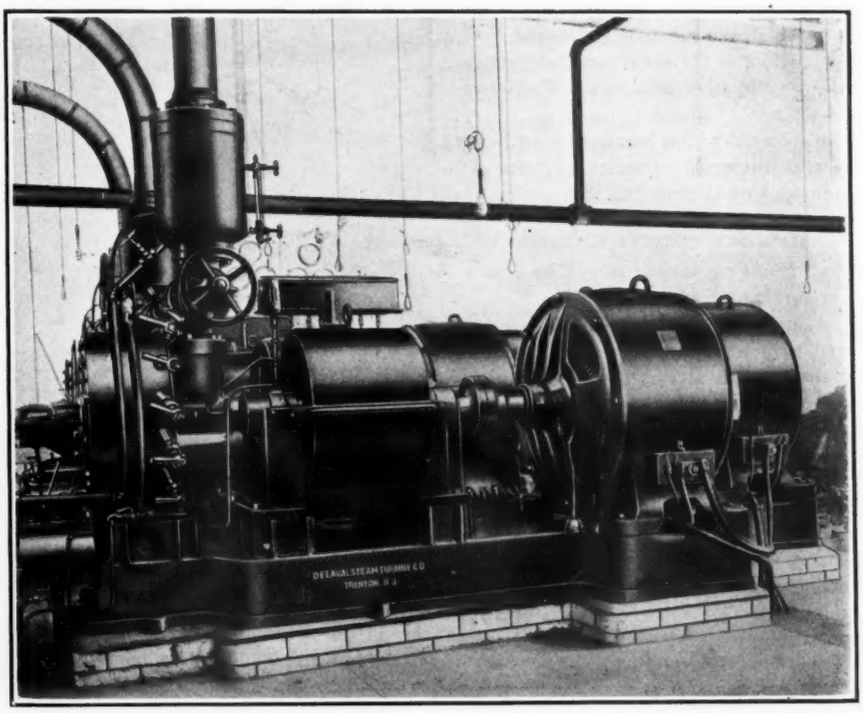


FIG. 1. ONE OF THE GENERATING UNITS

The boiler room is equipped with Heine water-tube boilers (Fig. 2) which

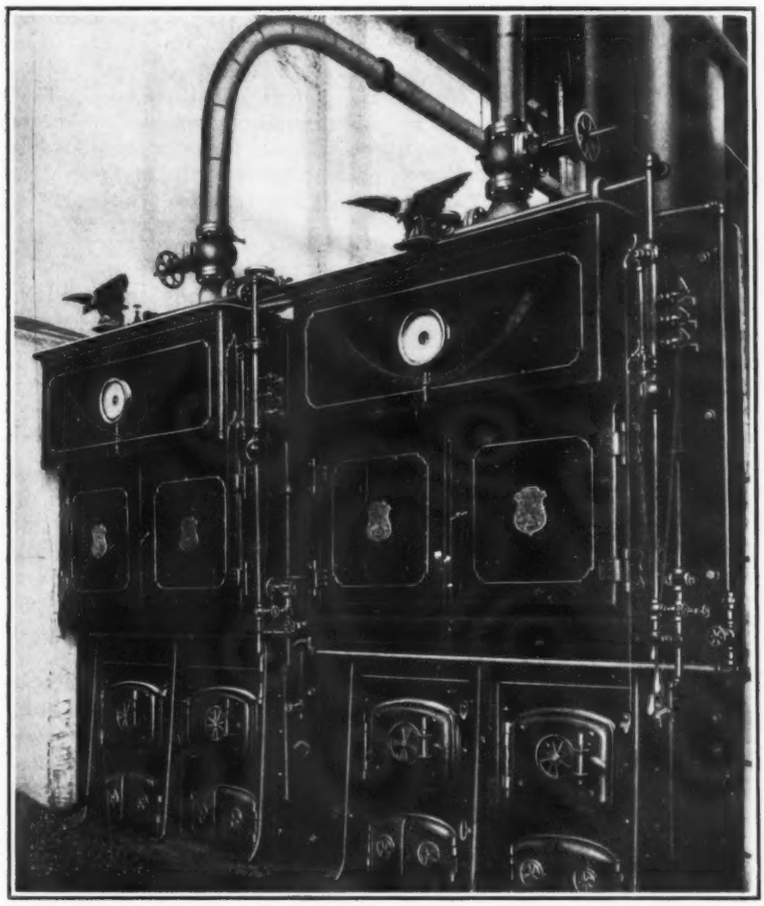


FIG. 2. THE BOILERS

supply steam at 165 pounds pressure, without superheat, to three DeLaval 150-horse-power turbines. Each turbine drives two 50-kilowatt generators through single-reduction 10 to 1 gears, the speed of the turbines being 12,000 and that of the generators 1200 revolutions per minute. The turbine runners are 20⅞ inches in diameter.

The generators are simple shunt-wound machines, with four field-magnet poles each. The armatures are of the usual toothed-core lap-wound type. The current density at the brush-faces is very moderate, being 26 to 27 amperes per square inch of contact at full load. The generators were built by the Western Electric Company, of Chicago and New York. Fig. 1 shows one of the generating units.

The turbines run condensing, of course. The condensing equipment consists of a C. H. Wheeler surface condenser having 2000 square feet of cooling surface, a Wheeler-Mullan valveless air pump (Fig. 3), two Wheeler-Pratt cooling towers and two centrifugal circulating pumps. One of the circulating pumps is driven by a 15-horse-power DeLaval turbine and is used for normal loads. The other, which is used alone during light loads and supplementarily during extra heavy loads, is driven by a 5-horse-power electric motor. The cooling towers (Fig. 4) are located on the roof of the building and under ordinary weather conditions are capable of cooling 1000 gallons of water per minute from condenser-discharge temperature to about 80 degrees Fahrenheit. The condensing plant maintains a vacuum of 26 to 27 inches under ordinary conditions.

A steam-driven blower is provided for increasing the boiler-furnace draft at heavy loads, and when this is running, the vacuum and circulating pumps are worked condensing, the exhaust steam from the blower engine being delivered to the feed-water heater; at other times the vacuum and centrifugal pumps run non-condensing and exhaust through the heater. The latter is a Cochrane open heater and raises the feed-water temperature to 180 to 200 degrees, according to operating conditions.

It is stated that a test of the plant at 80 per cent. of the rated output showed a steam consumption of 27.8 pounds per kilowatt-hour, the output being measured at the switchboard. This included all steam used by the auxiliaries.

At a recent meeting of the managers of the General Electric Company, Dr. Thomas Addison, manager of the Pacific-coast territory, reported a recent order for a Curtis steam turbine-generator which will have a normal capacity of 20,000 horse-power.

This is the largest capacity thus far put into a single steam-turbine unit and is equal to the rating of the largest hydraulic unit ever built.

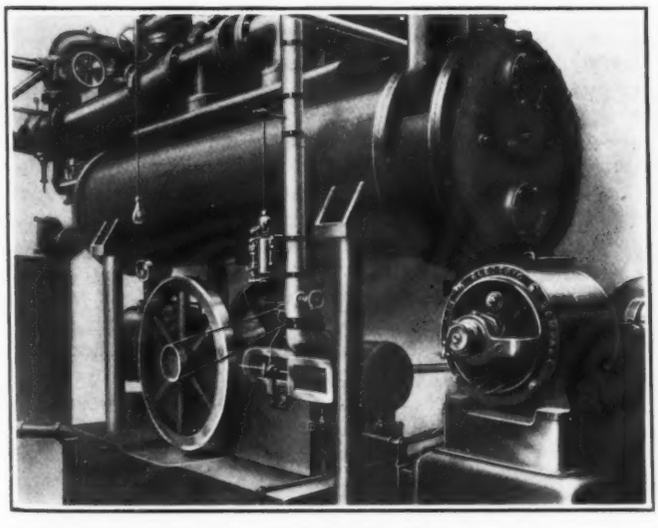


FIG. 3. CONDENSER EQUIPMENT

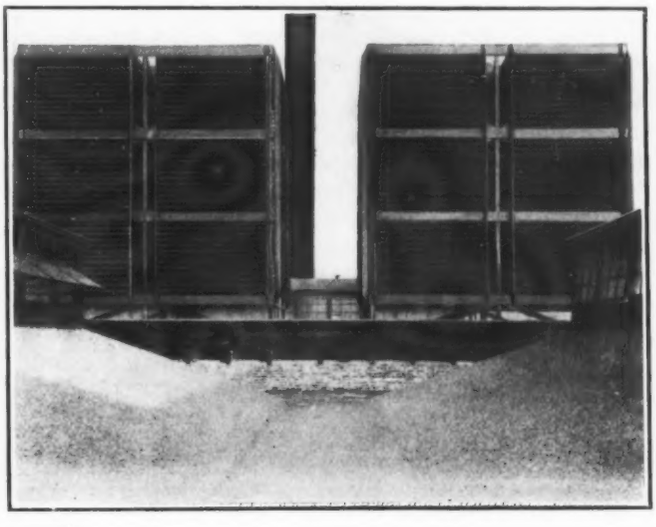


FIG. 4. COOLING TOWERS

Tests of a Murray-Corliss Engine

The accompanying table and diagram give the principal results of five tests made at the Iowa State College on an 18x36 Murray-Corliss engine, rolling-mill type, direct-connected to a 150-kilowatt 30-phase alternating-current generator. The tests were made by the senior students, under direction of the faculty, a few days after the engine was first started, and the data obtained were used in the students' theses.

The exact values of the observed results are shown by the small circles on the diagram and the solid-line curve connects these. For convenience in estimating the probable performance of this or similar engines under conditions beyond the scope of the experiments, these curves have been extended by dotted lines.

It should be noted that the engine was loaded beyond its most economical point when carrying a full load on the generator. This is the result of the low steam pressure, 112 pounds, the most economical load under these conditions being about 235 indicated horse-power, with about 42.3 mean effective pressure and about 0.18 cut-off; whereas if the engine had been supplied with steam of 130 pounds gage at the cylinder, a mean effective pressure of about 50 pounds per square inch would have been obtained, with a cut-off of about 0.16, no doubt with better economy.

It will be noted that the "scale of parts of the most economical load on the engine" does not coincide with the "scale of parts of rated capacity of the generator." If the engine had been supplied with steam at a suitable pressure, such as 130 pounds, the unit points of the scale would have coincided, but the other points would not even then have been over each other, owing to the efficiency of the unit as a whole varying with the load. This is a point which is often overlooked and should be watched carefully.

The variation of speed with the load is very clearly shown and proved to be well within the 2 per cent. from mean ordinarily specified.

The most important point shown, of course, is the excellent steam economy, as low as 23.82 pounds of dry steam per indicated horse-power-hour, with only 112 pounds initial pressure. The estimated steam consumption of the builder for such an engine at best load is 26.2 pounds, the results of the test being 2.38 pounds less (about 9 per cent.).

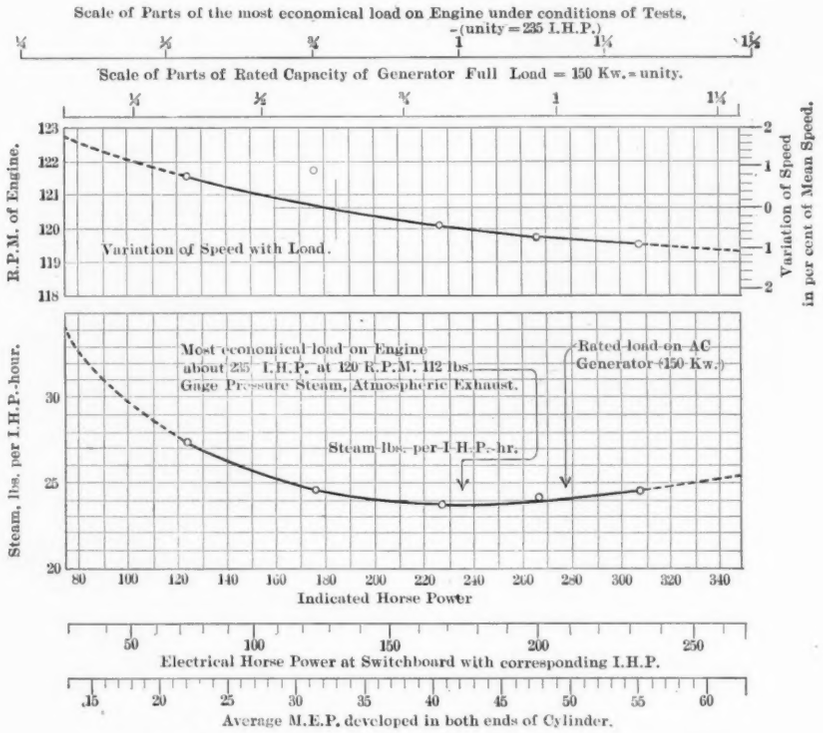

Scale of Parts of the most economical load on Engine under conditions of Tests, -(unity = 235 I.H.P.)
Scale of Parts of Rated Capacity of Generator Full Load = 150 Kw. = unity.
R.P.M. of Engine.
Variation of Speed with Load.
Variation of Speed in per cent of Mean Speed.
Most economical load on Engine about 235 I.H.P. at 120 R.P.M. 112 lbs. Gage Pressure Steam, Atmospheric Exhaust.
Rated load on AC Generator (150 Kw.)
Steam-lbs.-per-I.H.P.-hr.
Steam, lbs. per I.H.P.-hour.
Indicated Horse Power
Electrical Horse Power at Switchboard with corresponding I.H.P.
Average M.E.P. developed in both ends of Cylinder.

DIAGRAM SHOWING RESULTS OF TESTS OF A MURRAY-CORLISS ENGINE

TESTS OF MURRAY 18x36 "R M T" CORLISS NO. 2900 OF AMES, IOWA.

Carrying a 150-Kw. 3-phase A. C. Generator on its Shaft and Driving a 15-Kw. D. C. Exciter by Belt.

Line Reference No.			1	2	3	4	5
	1	Run No.					
	2	Total I.H.P. of engine	122.98	169.81	223.45	263.53	306.79
	3	Average R.P.M. on test	121.56	121.58	120.00	119.80	119.73
	4	Steam pressure per gage lbs.	111.8	115.04	112.4	112.2	113.6
	5	Electrical H.P. at switchboard	71 95	119.6	167.0	203.0	235.1
	6	Total dry steam Per I.H.P. hr. lbs.	27.39	24.74	23.82	24 25	24.51
	7	Total dry steam Per Kw. hr. lbs.	70.5	50.8	45.6	44.98	45.6
	8	Efficie'y of unit = (E.H.P.) ÷ (I.H.P.)	0.52	0.653	0.6998	0.7222	0.7272
	9	Mechanical efficiency of engine	0.6994	0 788	0.819	0.833	0.8308
	10	M.E.P. lbs. per sq.in. Head end	21.04	25.33	40.36	48.48	57.72
	11	M.E.P. lbs. per sq.in. Crank end	23.46	36.27	41.57	48.20	54.84
	12	M.E.P. lbs. per sq.in. Average	22.25	30 80	40 47	48.34	56.28

Renewing Tubes in a Horizontal Tubular Boiler

By J. E. Sexton

While the renewal of boiler tubes is properly the work of the boiler maker, the engineer who knows how to and can do it is just so much more valuable to the employer. The purpose of this article is to describe the method employed by the writer, together with the tools required.

First, it is essential to place a distinguishing mark on the front and rear heads to show which tube is to be cut out, using chalk or soapstone for the purpose, and the best way to make sure that the helper at the other end of the boiler marks the same tube that you do is to run through a strip of wood four or five inches longer than the tube. As such a strip is of use farther along in the process I make a length of 7/8x2-inch pine to serve both purposes. Next, with a hammer and a heavy cape chisel having a wide cutting edge, which is less liable to cut or mar the boiler (see Fig. 1), face the beads on both ends of the old tube until they are flush with the heads of the boiler. Then, at the front head, with a diamond-point chisel such as is shown in Fig. 2, cut a slot or channel, 1/16 inch wide, in the bottom of the tube extending inward to about 3/8 of an inch beyond the inner edge of the head, making sure that the groove is cut in the tube only and that the head is not cut or even marked by the chisel. *Do not drive the chisel clear through the tube, either.*

With an offset chisel, Fig. 3, carefully turn up the edges of the tube at both sides of the cut, until the tube-end resembles the condition shown in Fig. 4, when it will be found that this end of the tube has been released from the head. In cutting the slot, especially after the cutting edge of the chisel has gone beyond the thickness of the head, if the chisel is allowed to go through the tube it will be the source of considerable trouble, as it will cause the tube to spread. Hence, at this point extreme care must be used.

If a tube is corroded and muddy, it will be harder to remove and the method will have to be changed somewhat. Considerable force is required sometimes to remove such a tube. Instead of one slot in the bottom of the tube, two are cut, about 3/8 of an inch apart, and the

offset chisel is used as before, except that the 3/8-inch piece is turned up until it looks like the letter C, with its back toward the front of the boiler. Then proceed as before, turning the edges of the cut upward as far as they will go. A hook on the end of a chain or rope may then be inserted in the loop formed by the C-piece. This takes care of the front end.

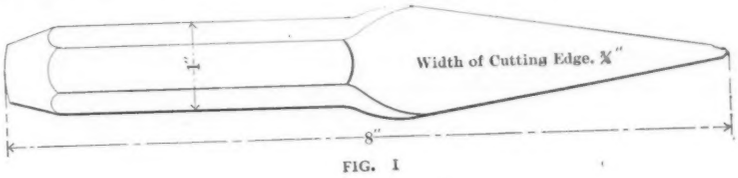


FIG. 1

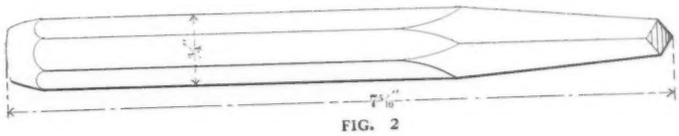


FIG. 2

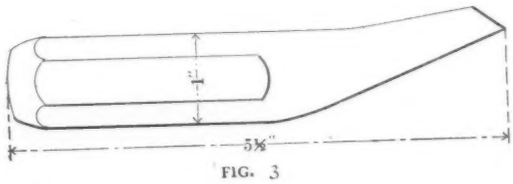


FIG. 3

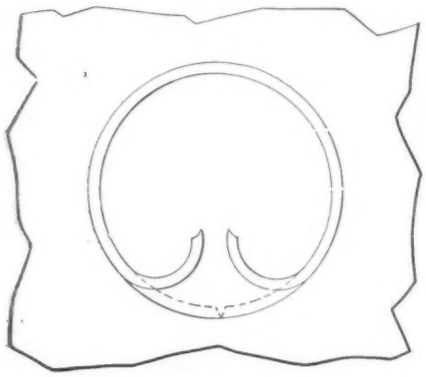


FIG. 4

At the other end of the tube insert the end of a piece of shafting about 10 inches long and a little smaller in diameter than the outside diameter of the tube. The end of this shafting should be turned so that it will enter the tube about one inch, with an easy fit, and by giving a few taps on the outer end of this improvised mandrel the tube will be loosened at this end. Then, by working the tube backward and forward it can be released altogether.

The next step is to mark the new tube so it can be cut to length. Insert the 3/8x2-inch piece of pine into the holes the old tube came out of until one end of the strip extends through the rear head about 5/32 of an inch. Hold it there and proceed to place a mark on the end extending from the front head 5/32 of an inch from face of the head. This gives the proper length to which to cut the new tube. Then, while the tube is being cut to length, take a half-round second-cut file, or a finish-cut file, and carefully smooth up the heads around the holes, removing any marks or cuts which may have been made in taking out the old tube. This is to prevent future leaks. Next, push the new tubes into place and station the helper at the rear end with a tube expander, being sure that the ends of the tube are equi-distant from the heads. It is advisable to insert one end of an 8-foot section of 1-inch pipe in the front end of the tube, for a distance of 12 inches or so, and exert a downward pressure on the lever so provided to prevent the tube from turning while the rear end is being expanded. As soon as the tube is tight at the rear end, proceed to expand the front end.

A self-feeding expander, Fig. 5, will give good results, especially if a ratchet wrench is used to turn the spindle, for one can tell by the feeling just when to stop expanding. A monkey wrench will do, however, if a ratchet wrench is not available.

The beading comes next. This requires a special tool similar to that shown in Fig. 6. Place the long prong of the tool inside the tube, with the short prong pressing against the tube-end. Then bead the tube-end thoroughly *throughout the circumference,* for if it is only beaded here and there it will prove very unsatisfactory. When both ends are beaded, use the expander lightly in each end once more, to remove the marks made by the beader.

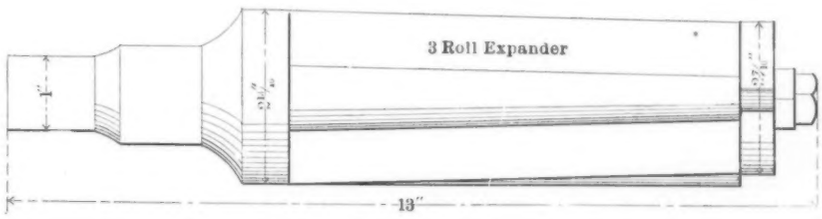


FIG. 5. TUBE EXPANDER

If both hand-hole plates are tight and the blow-off valve works O. K., fill the boiler with either hot or cold water, until the tube is covered, and if the tube does not leak water it will hold steam, and the boiler is ready to put into commission. If the tube leaks, re-expand it very lightly. Ordinarily, a man and helper can renew a tube in an hour, with ease.

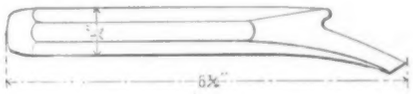


FIG. 6

New Home of the American School of Correspondence

The American School of Correspondence, of Chicago, Ill., has a handsome new four-story building located within a couple of blocks of the Chicago University, on the south side of the city. The building is arranged somewhat like the letter E, with east and west wings which partially inclose a courtyard 60 feet square, walled at the back and entered through an arched driveway. The second floor of the structure is occupied by the administrative offices of the school, including the lecture room, the other three floors being used to accommodate the instructors, editors and other employees.

In the basement are the stock room, shipping room and steam-heating plant. The system of heating employed is the "direct-indirect." Electricity is employed throughout for lighting, Nernst lamps being used in the corridors and larger rooms. To facilitate the work of the business office and mailing room the latest electrical appliances have been installed.

In addition to using the lecture room for school purposes it is the meeting place of employees' clubs which have been formed at the works of the Crane Company, the McCormick Harvester Company and other large manufacturing plants in Chicago and vicinity.

The materials of which the building is composed and its ornamentation are in keeping with the attractiveness of the neighborhood in which it is located.

Mechanical Production of Low Temperature

Why Power Is Required and Why Heat Is Employed in Refrigeration Processes; Heat Transference and Latent Heat Explained

BY SYDNEY F. WALKER

It is always puzzling to the layman or student, when approaching the problem of mechanical production of low temperature, the art of "refrigeration," as it is called, to find that power and heat are employed. In the absorption system, such as was described in the April number of POWER, page 236, heat is applied directly through the agency of steam, while in the compression system it is employed indirectly, either through steam required to operate the engine which drives the compressor, or through steam used in the generating unit which furnishes current for the motor which drives the compressor. In all cooling systems, whether so-called artificial, or so-called natural, that is to say, whether the system is under the control of the engineer and cooling is produced by the aid of mechanical appliances, or whether it is brought about by the ordinary courses of nature, a fluid agent is always employed to abstract heat from the substance that is to be cooled and deliver it to some other substance whose temperature is thereby increased. Further, in the movement of the agent employed, power or energy is always expended, and this is true whether the power be delivered by appliances under the control of the engineer, or by what we understand as the "force of nature."

The most striking instance of this action in nature is afforded by the polar winds which blow over the great continents, and, except where intercepted by mountain ranges, gradually extend the snow lines farther south. These cold winds abstract heat from all things in their paths, rendering each object colder and colder, and leaving frozen rivers and masses of snow in their wakes. The winds carry the heat so abstracted to the warmer regions of the south, where it is added to the heat which has been generated by the sun's rays. Furthermore, the passage of cold winds from the pole to the lower latitudes is caused by differences in barometric pressure, the winds only moving when such differences occur, a definite expenditure of energy being required to actuate them.

THE TRANSFERENCE OF HEAT

All substances have a definite capacity for absorbing heat, with a given rise of temperature. The capacity of pure water for absorbing heat at its greatest density, 39.1 degrees Fahrenheit, is taken as the standard for measurement. The heat unit, or, more accurately, the British thermal unit, is that quantity of heat required to raise the temperature of one pound of pure water from 39 degrees Fahrenheit to 40 degrees Fahrenheit. Every other substance absorbs heat in a similar manner, and its capacity to do so bears a definite ratio to that of water, this ratio being called the specific heat of the substance. Thus, the specific heat of air, under the conditions in which it occurs in the atmosphere, is 0.2375, which means that a little more than four pounds of air will have its temperature raised one degree Fahrenheit by the delivery to it of one British thermal unit. As air measures 13.141 cubic feet to the pound at 62 degrees Fahrenheit temperature, the delivery of one British thermal unit to any body of air will raise the temperature of about 52½ cubic feet of the fluid 1 degree Fahrenheit.

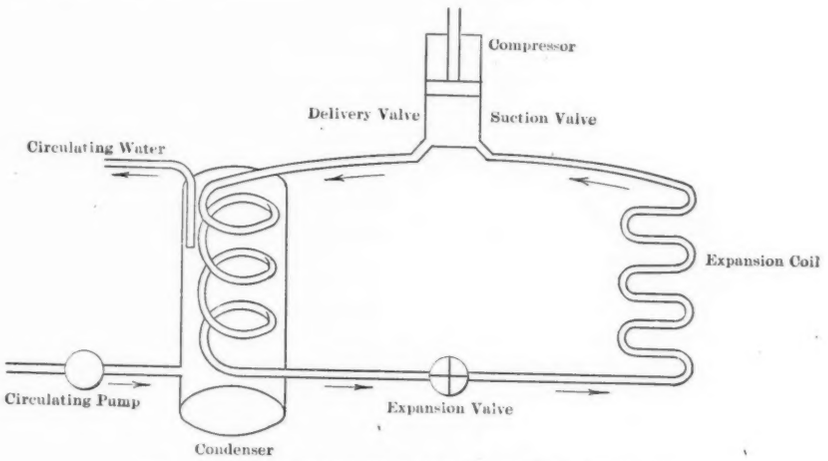


FIG. 1. ARRANGEMENT OF A SIMPLE COMPRESSOR PLANT

Heat always passes from a body at a higher temperature to one at a lower temperature, when the two are in contact, the rate at which it passes being directly as the difference of temperature between the two. Therefore it will be easily understood what a very large cooling effect the passage of the polar winds, which are at first at a very much lower temperature than the earth over which they pass, must have upon the substances with which they come in contact. Every cubic foot of air in passing will absorb a certain quantity of heat from the earth and other objects, such as the walls and roofs of houses, trees, men and other animals, in direct proportion to the difference between the temperature of the air and the temperature of the bodies over which it passes.

Another illustration of the transference of heat by the aid of fluids is afforded by steam-plant operation. The flue gases absorb heat liberated from the fuel in the furnace and transmit it through the heating surfaces of the boiler to the water. The steam in turn transmits the heat from the boiler to the engine; also, the tube walls of the condenser transmit the heat of the steam to the cooling water and thence to the body of water to which it is delivered. In each case work has to be expended upon the transmitting agent. In the case of the boiler-flue gases a definite portion of the energy liberated by the combustion of the fuel is utilized in drawing the air through the furnace and in carrying the flue gases themselves through the flues (or around the tubes in a water-tube boiler), the power so expended being definitely measurable.

The absorption of heat from the furnace by the flue gases confers upon them the power of doing work, in virtue of the presence of the heat, and this power is transmitted by the flue gases to the steam, and so on.

A similar reasoning holds in the case of refrigerating apparatus, although the apparatus itself is apparently different. All bodies, even if apparently cold, contain a certain quantity of heat, and in order that they may be cooled to a certain temperature a certain definite quantity of heat must be extracted from them. In case water is to be frozen, supposing that its initial temperature is 70 degrees, which is the average temperature of water employed in America for condensing purposes, 38 heat units must be abstracted from every pound of the water, or, say, 316 heat units from every gallon, in order

to reduce it to 32 degrees Fahrenheit, and this is done, as will be explained, by the passage of a fluid in the neighborhood of the water to be frozen.

Latent Heat

Another property in connection with the freezing of bodies, and which is also made use of in the agents employed to extract the heat from the bodies to be frozen, or lowered in temperature, is latent heat. It is well known that while approximately one heat unit must be expended for each degree rise in temperature between 32 degrees and the boiling point of water, when the boiling point is reached and the water is converted into steam, 966 heat units are absorbed by the same pound of water in order to convert it into steam of the same temperature as the water from which the steam is formed. These 966 heat units constitute what is known as the latent, or invisible, heat of steam. Similarly, when water is converted into ice, the temperature of the water is lowered by one degree for approximately each heat unit, down to the temperature of the freezing point, when the forming ice and the water of which it is being formed are of the same temperature, but in order to freeze it 142.4 heat units have to be extracted from each pound.

In the practical manufacture of ice, and also in nature's great ice factory, the process is always carried below the freezing point, the temperature of the ice being considerably lowered by the further abstraction of heat, to insure solidarity or stability. The specific heat of ice is only 0.504, or approximately one-half that of water, and therefore only one-half of one heat unit has to be abstracted from each pound of ice to lower its temperature 1 degree Fahrenheit. The temperature of mechanically produced ice, after formation, is lowered to about 15 degrees Fahrenheit, while naturally produced ice often reaches a much lower temperature. Ice at 32 degrees Fahrenheit, or even a little below that, is liable to become converted into water, through friction, or slightly increased temperature of the surrounding atmosphere, or other cause.

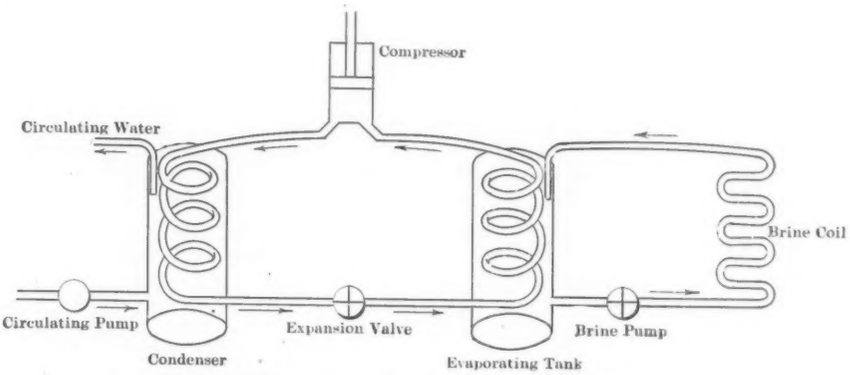


FIG. 2. ARRANGEMENT OF A COMPRESSOR PLANT WITH BRINE CIRCULATION

Carbonic acid, ammonia, sulphuric acid, ether, and a few other substances of gaseous origin are employed in the mechanical production of low temperature, because they are so readily converted from the gaseous to the liquid state and *vice versa*. Any one of these substances, after it has been liquefied, can only be reformed into a gas if two conditions are present: if it has space in which to expand to the gaseous state, and if it can obtain the heat necessary to enable it to expand. One pound of carbonic acid at zero Fahrenheit requires the presence of 123.2 heat units to expand it to a gas; at the same temperature, one pound of liquid ammonia requires 555.5 heat units to expand it to the gaseous state, and to transform one pound of sulphurous acid requires 171.2 heat units. Ether and other substances referred to are not often used for mechanical refrigeration, except in hot climates.

The Process Described

In refrigerating apparatus, one of the three substances mentioned—carbonic acid, ammonia, sulphuric acid—is employed to extract heat either from the air of a cold chamber and its contents, or from the water from which ice is to be formed, by allowing the agent employed to expand from the liquid to the gaseous condition, inside of a coil of pipes provided for the purpose. The gaseous carbonic acid, ammonia, or sulphuric acid is then caused to pass to the compressor, thence to the condenser, where it is reconverted into liquid, and again sent through the evaporating coils, as they are called, in which it again takes the gaseous form, and so on almost indefinitely. Power, therefore, is required at every step of the process. When the liquid carbonic acid, or whatever is used, is admitted to the evaporating coils, it immediately expands in the space provided for it, and in so doing abstracts a proportionate amount of heat from the air of the cold chamber, or from the water, brine or other substance with which the pipe through which the gas is passing is in contact. The passage of the heat, from the substance to be cooled, to the liquid in the evaporating coils confers upon the latter the *power* of expanding, contributing largely to the process. Then, later, when the gas passes on to be reconverted to a liquid, an equivalent amount of work has to be done upon it.

The work done upon the gas in the compressor appears in the form of heat in the gas, raising its temperature from that it had assumed in the evaporating coils to a considerably higher degree, the actual temperature depending upon the conditions present. This work is measured by the heat liberated in the gas, and the power that must be delivered to the compressor piston is measured by the work done upon the gas plus the work demanded by the compressor

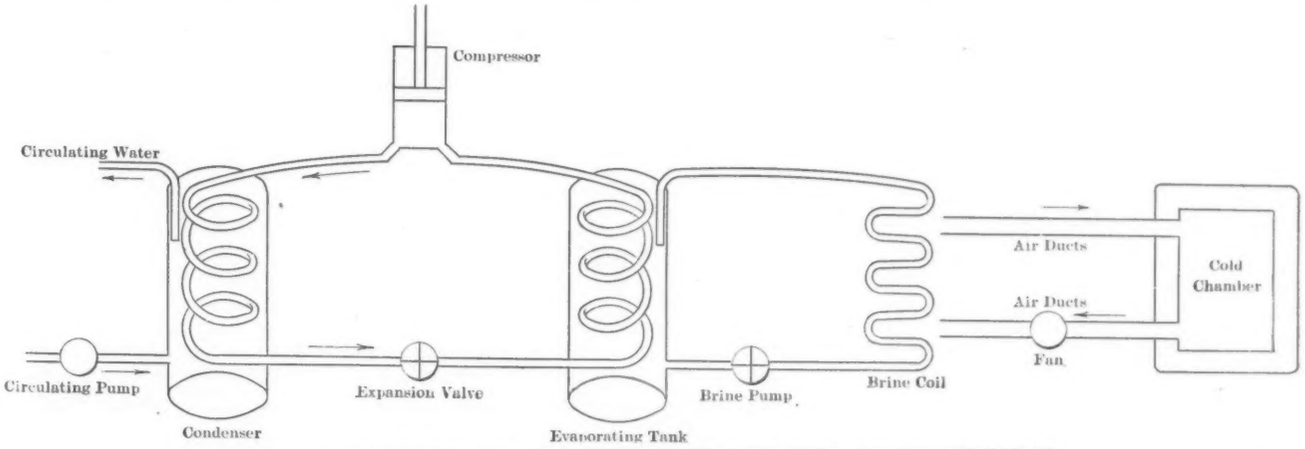


FIG. 3. ARRANGEMENT OF A COMPRESSOR PLANT, WITH BRINE AND AIR CIRCULATION

piston itself, necessary to overcome friction.

When the gas passes on to the condenser, it is converted to a liquid by exactly the same process by which steam is converted to water in a surface steam condenser, i.e., by the passage of water over the pipe through which the gas flows. The latent heat of the gas has to be abstracted from it, and in addition the heat that was delivered to it in the compressor, or, to state it in another way, the latent heat of the gas at the temperature and pressure at which it is delivered to the condenser by the compressor. For this purpose, circulating water has to be pumped through the condenser, just as in a steam condenser, and power is required to drive it, the power varying with the quantity of water needed, and the conditions under which the condenser works. More power is required with some types of condenser than with others, owing to the greater friction, although it is claimed for those in which the friction is greater that the efficiency is higher. The quantity of water required depends inversely upon its initial temperature.

A small quantity of power is necessary, also, to enable the compressor to perform its function as a pump to draw the gaseous refrigerant from the evaporating coils through the suction valves into the compressor cylinder. Often, too, power is required for driving brine through the evaporating tank and the cooling pipes.

Why and How Brine is Used

For many purposes it has been found advisable not to locate the evaporating coils in the room to be cooled, or in the tank from which ice is to be made, because, as in the case of ammonia, the escape of a small quantity of the gas through a leaky joint will have a serious effect upon the stored product and the forming ice. Frequently, therefore, a second fluid (in this case a liquid) is used to transmit the heat from the substance to be cooled to the evaporating tank. The liquid so employed is technically called "brine." It consists of a solution, usually of calcium chloride. It is necessary that this liquid should have a lower freezing point than the water which is to be frozen by its aid, and this is easily arranged by dissolving a certain quantity of the salt in the water to be used. The brine so formed is kept continually moving through pipes leading to the ice tank, or cold store, thence through pipes in the tanks, or stores, and back to the evaporating tank, power being required to drive the pump which produces this circulation, the power again depending upon the quantity of the brine to be moved, its velocity, and so on, in accordance with well-known laws.

In the most recent cold-storage plant, also, the air is cooled either by passing over pipes in which cold brine is circulating, over pipes in which a refrigerant is in course of expansion, or, more frequently, by passing through a battery of plates over which cooled brine is circulating, the brine taking up the moisture that has been brought by the air from the cold store, the air being circulated, by means of fan blowers, through ducts leading from the cold store to the cooling plant and back to the store again. Power is required for driving the fans.

The power required for the different apparatus mentioned necessarily varies with the differing conditions. As a rule more power is taken by each part of the apparatus when working in hot climates than in cooler ones. Again, more power is taken by each part of the apparatus if the design is bad, that is, if undue friction is allowed to be set up at any part, and if the velocity of any of the fluids employed is required to be increased to a considerable extent. The power required to move any fluid, it will be remembered, under any given conditions, varies directly as the square of the velocity of the fluid, and wherever the fluid is throttled the power required to move it increases very rapidly. There are laws governing the quantity of power required for each of the parts of the apparatus, and for each case that arises.

The accompanying sketches, Figs. 1, 2 and 3, show diagrammatically the usual arrangement of a simple compressor plant, of a compressor plant with brine circulation, and of a compressor plant with brine and air circulation, respectively.

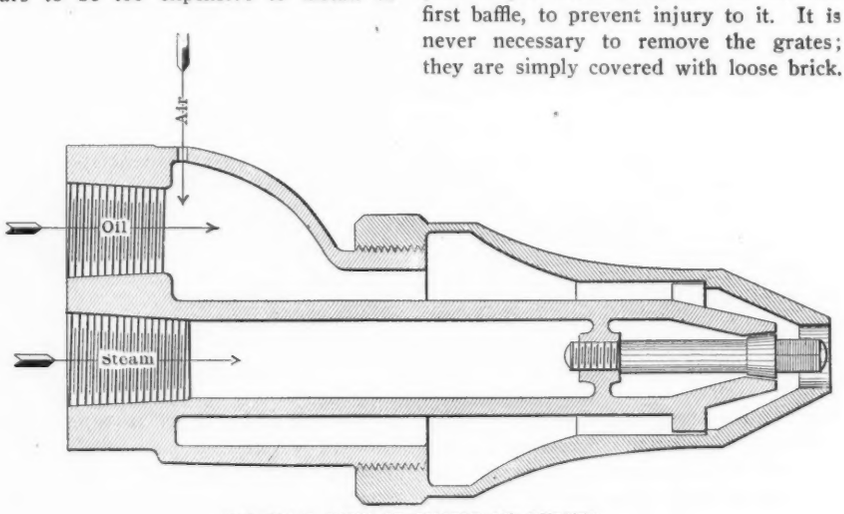
A Simple Oil-burning Plant

By J. E. Kent

Nearly every fuel-oil-burning system which the writer has seen described appears to be too expensive to install or combines so many complications that the average operating engineer is apt to look upon it as a bugbear. A crude-oil system is possible, however, which is reasonable in first cost and easy of operation, and which requires practically nothing for maintenance, besides presenting very few elements of danger. Such a system was originally designed to take the place of an old and troublesome arrangement for burning brick, and it was afterward installed under the boilers at the same plant, as well as at a number of other plants. With it no trouble of consequence has been encountered in making an abundance of steam, while at all times a perfectly clear stack has been maintained, and repairs to the boilers and costs of maintenance and attendance have been reduced to minimum.

The system consists of an oil burner, an oil-storage tank, a small steam pump and a simple piping lay-out. The oil is stored preferably in either a steel or brick cement-lined tank sunk in the ground and vented to the atmosphere. The steam pump is used to deliver the oil to the burners. A 4x3x5-inch single pump of the Burnham or Marsh type is a good size for a 500-horse-power plant. The discharge is piped directly to the burners, without passing through pre-heating coils or tanks, the oil being thoroughly heated in the burner to facilitate atomization by steam. The burner, a cross-section of which is shown herewith, is made in three pieces—the body, the shell and the regulating stem and nozzle. It is constructed entirely of brass.

Dry live steam is piped to the burner, and from 12 to 15 pounds of steam per hour is sufficient for a 200-horse-power boiler running at full-rated capacity. The flame is long and conical and under a 14-foot tubular boiler will reach nearly to the rear head. In a Stirling boiler setting a perforated brick wall is built in front of the tubes to keep the flame from striking them directly, and with Babcock & Wilcox boilers it is a good plan to pile loose brick in front of the first baffle, to prevent injury to it. It is never necessary to remove the grates; they are simply covered with loose brick.



SECTIONAL VIEW OF SIMPLE OIL BURNER

with ashes on top. The non-combustible in the oil drops on the ashes and in a short time forms an air-tight layer resembling a mass of dirty coal-tar.

Steam Turbines at the A. S. R. A. Convention

Latest Turbine Construction, Turbine Performance in Railway Service, and Developments in Turbine Power-station Work

BY CHILTON, KRUESI AND BIBBINS

At the recent meeting of the American Street Railway Association at Atlantic City three papers dealing with steam turbines were presented by representatives of each of the three builders of large units. The first in the order of their presentation was:

The Allis-Chalmers Paper

"Some Practical Points in Steam-turbine Construction, with Particular Reference to the Parsons Type," by St. John Chilton. Mr. Chilton is a member of the Allis - Chalmers Company's engineering staff, and the greater part of his paper was devoted to a description of the turbine built by that company, with the characteristics of which our readers are already acquainted.

Steam Pressure

The most economical operating pressure the author thought to be about 150 pounds above the atmosphere, a greater saving being attainable by the use of a small amount of superheat than by carrying the initial pressure above this point. Reliable data show the gain in steam economy by increasing the pressure from 150 to 175 pounds to be approximately 2 per cent.; an increase of pressure from 150 to 200 pounds improves the steam economy by approximately 3 per cent. Increasing the steam pressure has a tendency to increase rather than to reduce the cost of the turbine. The selection of the most economical steam pressure, therefore, resolves itself into a comparison of the cost of fuel and initial investment which ought to be made for definite conditions.

Since steam turbines have become better known the impression is not so common that higher vacuum is required to obtain economical results with this prime mover than with reciprocating engines, although the turbine can use high vacuum to better advantage. The difference in steam economy within the range between six inches and three inches absolute, i.e., between 24 and 27 inches of mercury, is approximately 5 per cent. per inch. The difference between two and three inches is approximately 6 per cent., and between two inches and one inch approximately 7 per cent. Theoretically, the effect upon the turbine of reducing the vacuum below that for which it is designed is to reduce the capacity and to lower the output at which maximum economy is obtained. In the reaction turbine, for a given initial pressure, lower operating vacuum permits of fewer rings of blades, likewise a smaller area of exhaust opening. Therefore the effect upon the cost of the turbine is to reduce rather than to increase it. The difference, however, is not sufficient to be of importance in determining the operating vacuum desirable.

Superheat

Steam-consumption tests show that the increment of saving becomes smaller as the superheat is increased. For 50 Fahrenheit degrees of superheat at the turbine throttle a reduction in steam consumption approximating 7 per cent. is effected. The reduction effected by 100 de-

TABLE 1. ANALYSES OF LOAD CURVES—COMBINED RAILWAY AND LIGHTING SYSTEMS.

		Average 24-hour Load.	Average Load When Running.	Unit. (1) Loading Factor, Per Cent. Rating.	(2) Max. Demand Factor.	(3) True Loading Factor.	(4) Station Loading Factor.
Saturday, Sept. 24.	Railway.	1,058	1,355	67.8	95	56	35.3
	Lighting.....	692	.....	34.6	89	39	23.0
(Curves)	Stati n..	1,850	.....	49.9	85	55	31.0
Sunday, Sept. 25.	Railway.....	921	1,034	50.2	75	61	30.6
	Lighting.....	471	.....	47.1	123	38	15.7
	Station.....	1,392	.....	53.0	88	53	23.2
Wednesday, Sept. 28.	Railway.....	1,050	1,230	61.5	75	70	35.0
	Lighting.....	634	.....	31.7	79	40	21.0
	Station.....	1,685	.....	45.4	72	58	28.0

(1) Average load when running—capacity of unit.
(2) Maximum demand from load curve—capacity running.
(3) Average 24-hour load—maximum from load curve.
(4) Average 24-hour load—station capacity, including one spare unit each 25- and 60-cycle.

TABLE 2. TESTS OF 9000-KW. CURTIS TURBO-GENERATOR AT CHICAGO.

Turbine five-stage, condenser base, 750 r.p.m., generator four-pole, 900 volts, three-phase, 25-cycle.

Load in Kilowatts.	Gage Pressure Lbs.	Vacuum Inches.	Superheat Deg. F.	Water Rate Lbs. Per Kw.-hr.
5,374.....	182	29.43	133	13.15
8,070.....	179	29.35	116	13.0
10,186.....	176	29.47	147	12.9
12,108.....	182	29.34	148	13.05
13,900.....	198	29.31	140	13.6

TABLE 3. COST OF COMPLETED POWER STATION. 8500 KW. NO SUB-STATION APPARATUS.

	Cost.	$=Kw.
Building: Including general concrete and steel work, galleries, coal bunker, smoke flue, condenser pit, coal storage pit, etc.....	$ 93,217	$10.97
Generating Plant: Including, turbines, generators, exciters, cables, switchboards, transformers and ventilating ducts.....	259,711	30.55
Boiler Plant: Including boilers, superheaters, stokers, piping, pumps, heaters, settings, breechings and tank.....	118,313	13.92
Condenser Plant: Including condensers, pumps, piping, free exhausts, water tunnels and intake screen.....	33,790	3.98
Coal Handling Plant: Including Gantry crane, crusher, motors and track.....	7,990	0.94
Erection Superintendence, Engineering and Miscellaneous.....	50,500	5.94
Total, excluding property and siding.....	$563,520	$66.25

grees approximates 10 per cent., and with 150 degrees it is 12½ per cent.

This saving is due in part to the maintenance of dryer steam and to a reduction of skin friction upon the blades. The effect of superheat upon a turbine designed for dry saturated steam would be to increase its capacity unless it caused a corresponding increase in volume. The increase in volume, however, is sufficient to maintain the capacity of the turbine practically unchanged.

In conclusion the author spoke of the possibilities of low-pressure turbines to be run by the exhaust steam of stations now running non-condensing.

The General Electric Paper

"Curtis Turbines in Railway Service" was the title of a paper by August H. Kruesi, an engineer of the General Electric Company. Mr. Kruesi introduced his paper by emphasizing the adaptability of the steam turbine to the variable loads occurring in street-railway work. In the Curtis type of turbine built by his company, before the steam enters the wheel casing the pressure is reduced by expansion to about 50 pounds and the temperature to approximately the temperature of saturated steam at that pressure, so that the operating parts of the turbine are not subjected to wide variation in pressure and temperature with sudden fluctuations of the load.

Steam Consumption

Fig. 1 and Table 1 give the results obtained upon the tests of a 5000-kilowatt turbine-generator unit at the L-street station of the Boston Edison Company; Table 2, results of tests made on a 9000-kilowatt unit at the Fisk street station of the Commonwealth Electric Company, of Chicago; and Fig. 2, the acceptance test of a 2000-kilowatt unit for the West Jersey & Seashore Railroad Company. These tests indicate that the hourly steam consumption from no load to a point considerably above rated load follows a straight line when plotted to load and that the total consumption of steam includes a fixed amount (this being the amount required to maintain the machine at speed without load) plus an additional quantity proportional to the load. A high economy at light loads requires that the fixed amount required at no load shall be as small as possible. In the tests of the three machines referred to, it was found that this constant was, respectively, about 12.5, 7.1, and 14.2 per cent. of the steam consumption at full load, and the economy curves are correspondingly flat over a wide range in load. A first-class reciprocating-engine unit would probably have a no-load steam consumption of not less than 15 per cent. of that required at rated load. The additional quantity of steam per kilowatt over and above this fixed amount at no load is 12.1 pounds per hour in the case of the Boston Edison test. Steam at the pressure and the superheat employed in these tests expanding to 1.5 pounds absolute pressure would generate one kilowatt for 9.27 pounds per hour in a theoretically perfect steam engine or turbine driving a generator of 100 per cent. efficiency. It will be seen that, barring the unavoidable no-load losses, the efficiency of the turbine amounts to about 76.4 per cent. of that theoretically obtainable.

Rating of Turbine Generators

When provision for ventilation is made it is possible to generate larger amounts of power continuously in individual machines and thereby very materially to reduce not only the initial cost of the station but the operating cost. Turbines were formerly designed to carry approximately full load non-condensing and in consequence had a very large margin of output when run condensing. Experience demonstrates that the non-condensing capacity is of little value. Engines when designed for the most economical performance at rated loads necessarily have a large overload capacity, but operate when overloaded at relatively very poor economy, and can only be used advantageously at overloads for comparatively short periods. Generators for engines have accordingly been designed with an overload capacity of 50 per cent. for two hours only. The fundamental difference in this respect between engines and the turbines under discussion calls for an entirely different ratio between generator and prime-mover capacities. Generators to be used with turbines should permit the set to be operated continuously at a larger proportion of the maximum output of the turbine. Generators of the larger capacity will show an appreciably better efficiency than those of the older rating. The economy of operating a turbine at the larger capacity has already been pointed out. Such a ratio of capacities naturally must change the basis of rating. If the generator's continuous capacity is to be made more nearly that of the turbine, a smaller margin in temperature rise need be made for protracted overload.

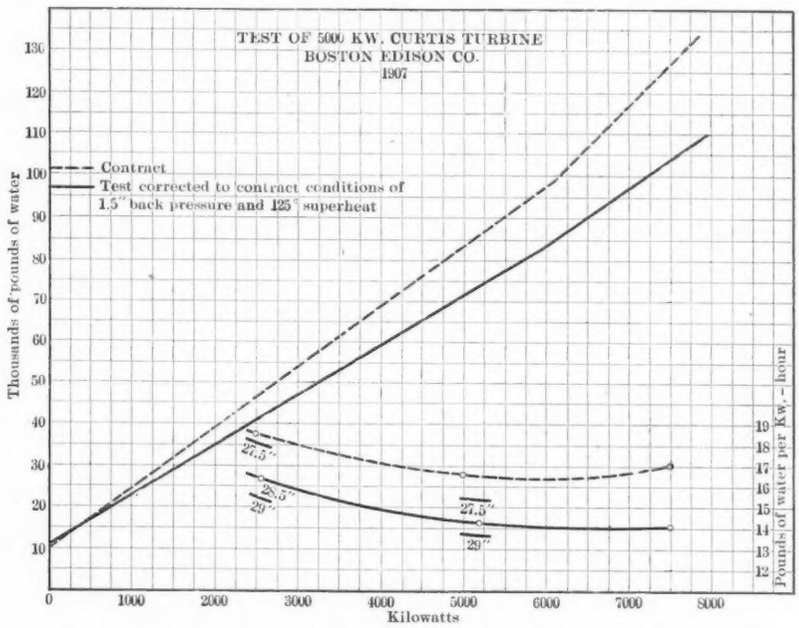


FIG. 1. TESTS BY BOSTON EDISON COMPANY ON 5000-KW., 750-R.P.M., 60-CYCLE 6900-VOLT CURTIS TURBINE-GENERATOR

Governing

All of the large 25-cycle turbines are now equipped with hydraulically operated valves controlled by balanced pilot valves connected to the governor and taking oil from the step-bearing pumping system. These governors and valves have proved reliable, permanent in adjustment, sensitive and responsive to abrupt changes in load and require very little attention in operation. They represent probably the greatest single improvement which has been effected in this type of turbine. They are ordinarily set for 2 per cent. change in speed and this degree of regulation is found sufficiently large to afford stable operation in parallel. It is the usual experience that after being adjusted for the correct speed at the factory, they seldom require alteration of speed or regulation when new machines are set up and paralleled with machines of the same type already in operation.

The very considerable kinetic energy of these turbines and generators (far exceeding that of the fly-wheel and generator of engine-driven sets of the same capacity) contributes very largely to their responsiveness to extraordinary fluctuations of load and to their close speed regulation. As an example, the 3500-kilowatt 750 revolutions per minute 13,200-volt set has a total fly-wheel effect, WR^2, of approximately 320,000, and this represents at rated speed a stored energy of 30,600,000

foot-pounds by virtue of which the machine when working at any load can carry an additional load equal to the full rating for about 0.75 of a second with a drop in speed of 3 per cent. and without additional steam, or a momentary increase in load of half the rating for 1.5 seconds, thus affording the governor plenty of time in which to act even if it were for any reason sluggish.

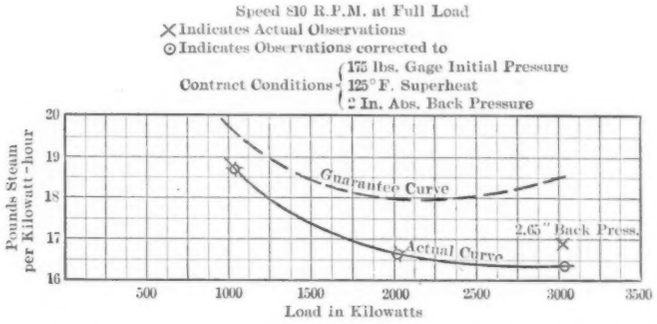

Speed 810 R.P.M. at Full Load
× Indicates Actual Observations
⊙ Indicates Observations corrected to
Contract Conditions { 175 lbs. Gage Initial Pressure
125° F. Superheat
2 In. Abs. Back Pressure
Pounds Steam per Kilowatt-hour
Guarantee Curve
Actual Curve
2.65" Back Press.
Load in Kilowatts

FIG. 2. ACCEPTANCE TEST ON A 2000-KW., 810-R.P.M., 25-CYCLE CURTIS TURBINE

LUBRICATION

The step-bearings of these machines are now lubricated with oil instead of water which was formerly employed. The change to oil involves the use of an additional shaft packing where the turbine shaft passes through the base, but as this packing has only to seal against the atmosphere its duty is relatively light and its operation simple. The upper bearings of these machines are now being lubricated under pressure from the step-oiling system dispensing with tanks and sight-feed glasses. The pressure lubrication enables the bearings to be supplied with any quantity of oil desired. It is found that a flooded condition of lubrication in the guide bearings materially improves the operation of the machines as regards freedom from vibration. The oil is filtered continuously and an ordinary grade of mineral engine oil is satisfactory. Its specific gravity at 20 degrees Centigrade should be about 0.89 and its viscosity between 0.6 and 0.95 measured by the pipette viscosimeter.

PRESSURE, VACUUM AND SUPERHEAT

Steam working from 200 pounds gage to 28 inches vacuum makes available about 5 per cent. more energy than steam at 150 pounds pressure while it requires only about 0.6 of 1 per cent. more heat making a theoretical gain of about 4.4 per cent. due to this increase in pressure. The actual improvement in the economy of the turbine due to this increase would be about the same. Practically all of this is realizable inasmuch as the efficiency of the boilers under these two pressures would be substantially the same.

The addition of 100 degrees of superheat adds about 4.5 per cent. to the total heat of the steam and would require an extra fuel expenditure of approximately 6 per cent. and makes a reduction of about 8 per cent. in the steam consumption of the turbine, resulting in a net gain on this account of approximately 2 per cent.

This, however, does not represent the whole gain due to the use of superheat as compared with ordinary saturated steam operation, because such steam is never dry and a small amount of moisture causes an altogether disproportionate increase in steam consumption. The first 50 degrees of superheat is of appreciably greater value than the second 50 degrees. While higher superheat will undoubtedly result in proportionately increased net economy its employment must in a large degree be dependent not only upon the load factor and the size of unit to be employed but also upon the nature of the service as regards severe and frequent variations in load, in view of the difficulties which have been encountered in the practical operation of superheaters, steam piping, valves, pumps and engine-driven auxiliary machinery.

It seems probable that much of the trouble which has undoubtedly attended the use of superheated steam is due not to any want of strength, but to want of elasticity in the parts affected and that they are not the result of high temperature so much as the unceasing variation in temperature incidental to the ordinary railway load. It is now generally believed that water may exist under certain conditions in the presence of superheated steam and if variations in load cause occasional priming of the boilers and water in the steam piping the resulting variation in temperature due to the spraying of heated surfaces is enormously increased. The substitution of annealed steel castings in place of cast-iron fittings and valve bodies, the omission of copper gaskets and copper alloy internal parts in valves, better design of boilers and superheaters so that the boilers will deliver only steam and no water to the superheaters and so that water can readily drain out of the superheaters and piping, are all factors which will permit the satisfactory employment of higher degrees of superheat.

The low velocities in steam piping which have become customary by reason of the pulsating flow of steam engines are not suitable for superheated steam. It is essential that the piping be made flexible to the greatest practicable degree and this requires small sizes of pipe. The steam pipes for Curtis turbines will require velocities of about 8500 feet per minute at their maximum ratings, based on saturated steam. One hundred degrees superheat will increase the volume of the steam about 15 per cent., but the velocity will be substantially the same on account of the reduction in the steam consumption of the turbine. The use of higher pressure and superheat will be facilitated by the introduction of steam-turbine driven pumps and auxiliary machinery, and a satisfactory beginning has already been made in this direction in the shape of a high-speed centrifugal circulating pump driven by a 75-kilowatt horizontal Curtis turbine for the condenser of the fourth 2000-kilowatt unit in the Westville power station of the West Jersey & Seashore railroad.

Improvement in economy arising from better vacuum is probably the most easily attained. Raising the vacuum from 28 inches to 28.5 inches makes 5 per cent. more energy available and of this the turbine realizes an improvement of from 0.5 to 0.6 pound per kilowatt-hour at rated load, that is, from 2.5 per cent. to 3.5 per cent., depending on the economy of the unit. Another way of regarding this is to consider that it adds just so much to the capacity of the station. To improve the condensing equipment is often the easiest way to lighten the duty on the boilers.

DISCUSSION

Discussing Mr. Kreusi's paper, Mr. Roberts questioned whether the boiler companies would be willing to guarantee at 200 pounds the same boilers that they would sell for 150 pounds. He told of trouble which he had just been having with lap-welded tubes on some Stirling boilers running at 150 pounds. Only a few days before they had lost 64 tubes in one 300-horse-power boiler by the failure of

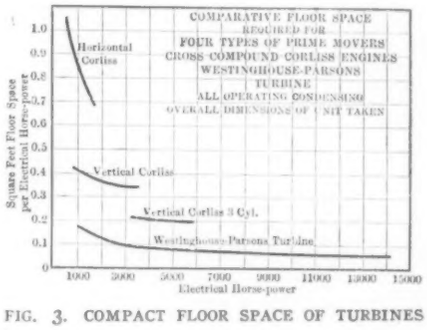


FIG. 3. COMPACT FLOOR SPACE OF TURBINES

the lap welds. One of the troubles that they had had with their turbine installation was taking care of the water of condensation in the exhaust line. There is no injector or pump that can pump against a vacuum. The turbine should be thoroughly warmed up, then slowed down or stopped and the water of

condensation removed before the final starting up. He told of an instance where owing to a drop in the pressure of the natural gas with which his boilers were supplied, the steam pressure fell from 150 to 85 pounds. The turbine continued right on with all the load that it could handle while the reciprocating engines were working with the valves held up and were inclined to "lay down."

He advised strongly against the use of the water step-bearing. The first turbine that they had had an oil step-bearing and they have had no trouble with it. Their water step-bearing consumed eight gallons of water per minute, which at 6 cents per thousand cubic feet amounts to an expenditure of about seven dollars in twenty-four hours, and this "would pay for an awful lot of oil." But further than that the impurities in the water seriously affected the surfaces of the bearing. An analysis of the water showed two grains of sulphate of manganese, seven grains of carbonate of lime and seven grains of sodium chloride per gallon. They have spent more on these turbines in renewals than on the rest of the plant, in that station during the last twelve months. They had to purchase sleeves in order to have bearings ready in case of needed renewal, and the carbon rings were also expensive. So far as auxiliaries are concerned he would not have a steam-driven circulating pump and he would have a barometric tube condenser. They are operating theirs without a dry-vacuum pump and are getting from 28 to 28½ inches at 1080 feet above sea level. His objection to the steam-driven pump, it developed later, was that it was occasionally necessary to drive the pump at a high rate of speed to force the water over the column in starting, and that engines designed for the normal speed of the pump made bad work of running at the excessive speed required.

P. D. Mitchell said that his company had two turbines in operation and used the water which comes from the step-bearing for boiler feed.

Mr. Roberts explained that in his case water from the step-bearing goes into the discharge end of the turbine and is lost, his being a barometric jet condenser.

Mr. Mitchell further explained that the water from the step-bearing in his plant was discharged into the exhaust end of the turbine, so that it went into the surface condenser and was available with the condensed steam for boiler feed. In his case the surface condensers had been very satisfactory; the circulating water was very dirty and the surface condensers provided them with an excellent boiler feed. Mr. Roberts retorted that the user of a surface condenser had to handle 70 pounds of water to condense a pound of steam, where it could be done with 30 pounds in a barometric tube condenser.

Charles Hewitt said that his plant was using water step-bearings and oil step-bearings, barometric tubes and surface condensers and his experience had not been such as to show a marked superiority for either.

F. E. Henshaw said that there were those who thought that electrically driven auxiliaries were dangerous; their efficiency is not as good as that of the steam-driven auxiliaries, and there are a good many reasons why it is better to have the auxiliaries directly driven by steam rather than to go around to the secondary source of power. He suggested that Mr. Roberts' trouble with the circulating pump might be overcome by driving it by a turbine, and referred to the multi-stage volute pumps which are being used at the New York Edison Waterside station and elsewhere, even for boiler feeds.

C. F. Baker suggested that Mr. Roberts' trouble with his pump might be overcome by increasing the size of the rotor of the pump, which would reduce the number of revolutions required per minute and thus the required speed of the engine. He also took exception to Mr. Roberts' intimation that he did not care for economizers; that, taken in connection with the electrically driven auxiliaries, they would be uneconomical. Without steam-driven auxiliaries as a source of steam for heating the feed-water, and at the same time no use of economizers, he would be feeding cold water to the boilers.

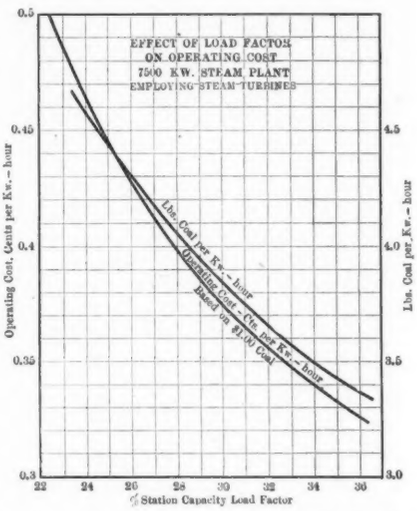

EFFECT OF LOAD FACTOR
ON OPERATING COST
7500 KW. STEAM PLANT
EMPLOYING STEAM TURBINES
Operating Cost, Cents per Kw.-hour
Lbs. Coal per Kw.-hour
Lbs. Coal per Kw.-hour
Operating Cost - Cts. per Kw.-hour
Based on $1.00 Coal
% Station Capacity Load Factor

FIG. 5. EFFECT OF LOAD FACTOR ON OPERATING COST

Dudley Farrand, of the Public Service Corporation of New Jersey, said that they had a variety of stations and a variety of engines and turbines. They had changed their turbine water step-bearings to oil bearings and he thought were getting better results. They were able to run with greater clearances, and the oil is a better lubricant. Their condensing water is salt, so that they use surface condensers and return the water to their boilers, and they found their feed-water temperature higher when they were using the water step-bearing. They have had generator troubles but no troubles whatever with the turbine end of the units. As to first cost, he did not see how any company could afford to put in anything but a turbine in large installations. The difference in first cost would provide a very much greater capacity and so far as the investment side is concerned there is no doubt about the advantage of the turbine. He preferred high-pressure steam-driven auxiliaries and to put in sufficient capacity so that they could be run at slow speed. It seemed to him foolish to take generator capacity and reduce it down to electric drive for the auxiliaries when you want the current in the mains. There are fewer complications to steam-driven apparatus.

Mr. Mitchell said that in the Edison station at New Orleans all the auxiliaries were originally electrically driven, but that all of this apparatus had been taken out and supplanted by steam-driven apparatus, which is now in use.

Mr. Farmer said that the experience of the Old Colony street railway had been

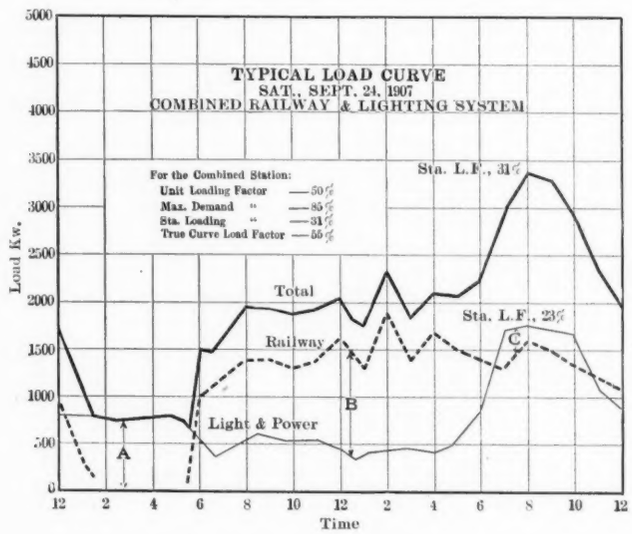


FIG. 4. TYPICAL LOAD CURVE

similar. They had some 10,000 kilowatts capacity of Curtis turbines installed at Quincy and three 500-kilowatt machines at Newport. At Quincy the auxiliaries were all electrically driven, but their experience was such that they soon changed one of them to a steam-driven type and when the fifth unit was added that was steam-driven, also. They found the operation was much more satisfactory where they had some steam-driven units, and there was not the emergency which might arise if the circuit-breakers of the auxiliary motors should shut them all down. Their circulating water was salt and they had to buy fresh water, so that it was advantageous to use surface condensers. Their step-bearing water was discharged

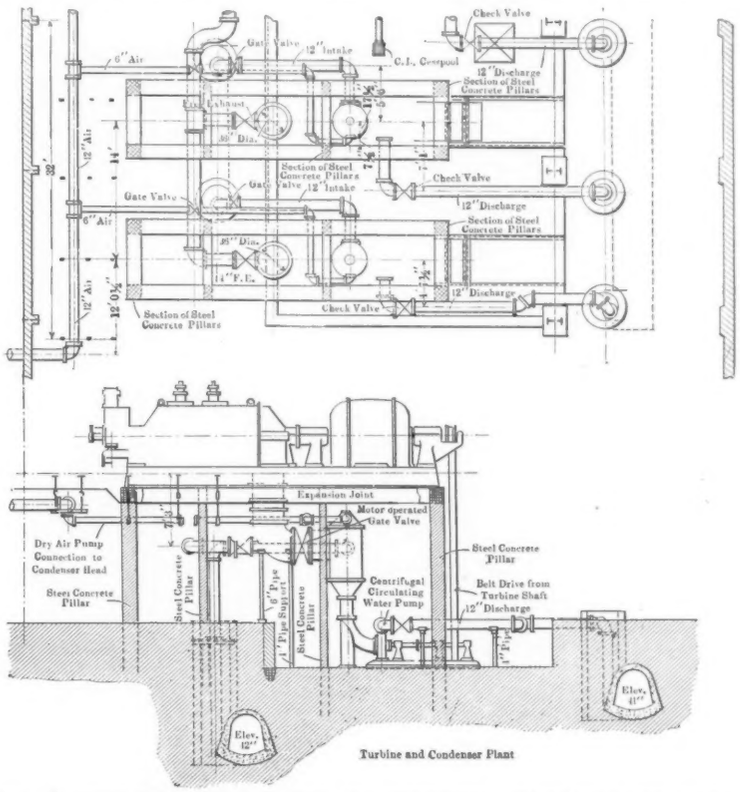


FIG. 6. CROSS-SECTION OF TURBINE AND CONDENSER ARRANGEMENT RELATIVE TO FOUNDATION

directly into the condensers and they had had no experience which would lead them to seek a change. They have also a unit with an oil step-bearing which has been equally satisfactory. In the case of the oil bearing there is a continual expense for oil, whereas with the water bearing, the water, with some degree of heat in it, went directly to the condenser and mingled with the feed-water. He asked Mr. Kreusi if the figures that he had given for the percentage in gains in economy for steam pressure, vacuum and superheat would apply generally to all sizes of machines. He figured out a gain of 0.88 per cent. in steam pressure for every 10 degrees rise in temperature and wondered if that applied to all sizes.

Mr. Mitchell asked Mr. Kreusi if he had any information as to the difference in economy between surface and barometric jet condensers as applied to turbine operation.

Mr. Kreusi in summing up said that there were more than one hundred machines operating with water step-bearings in various parts of the world, from Japan to South America and South Africa, and operating in a satisfactory condition. He thought that Mr. Roberts' trouble was due to the deposit of scale-forming material on the lower wheel, due to the spraying of the water in passing through the turbine, and that this deposit would throw the turbine out of balance. A similar case arose where good water was not available in Cuba and one or two other places, and it was necessary to design oil bearings for those machines. As the manufacturers did not want to maintain two or three designs of step-bearing, they changed everything to the oil step, and that is now the standard. Notwithstanding Mr. Roberts' unfortunate experience with the boiler tubes, they have boilers at work at 175 and 190 pounds all over the country. In the same way, he believed it was an error to condemn engine-driven circulating pumps because in one particular instance the pump was designed for too high a speed. A circulating pump for conditions such as Mr. Roberts had to deal with can be designed for a wide range of speed, and there is no reason why it should not be designed for 75 revolutions, as that happens to be the speed of the pumps in the Commonwealth station at Chicago. This speed was chosen so that the same engine could drive vacuum pumps which might run at slow speed. Motor-driven auxiliaries are open to the same objections as motor-generator exciter units. The experience has been that they are free from objections. Sufficient steam could be had for feed-water heating by taking steam from the first and second stages. All Curtis turbines are furnished with openings so that if anyone desires to heat water in that way it can be done. The turbine uses the steam down to the point where it is abstracted and has a higher efficiency than most of the engines which would be used for driving auxiliaries, so that it would be economical to use no steam-driven auxiliaries. There are other objections on the score of reliability with motor-driven auxiliaries which would offset that. He thought that turbine-driven auxiliaries were absolutely reliable; they have been used in several instances and he looked for a very rapid increase in the number of such auxiliaries in use. He had understood Mr. Roberts to say that on the score of reliability the reciprocating engine is to be preferred. Here again he thought it dangerous to draw a general conclusion from an isolated case. It was his observation that when a new installation was put in all the troubles are laid to the turbine. He thought that in Mr. Roberts' case, many of the troubles had been condenser troubles and not due to the turbine. As controverting Mr. Roberts' assertion that the engine was to be preferred to the turbine on the score of steam efficiency, he quoted the last report of the turbine committee of the Edison association to the effect that engines are no longer in the same class with turbines, as far as steam consumption is concerned. The figures of superheat, pressure and vacuum which he had given were general statements. The percentage of improvement would depend upon the size of the turbine under consideration, because a 1000-kilowatt unit, for example, would have a water rate of about 20 pounds, whereas a 5000-kilowatt unit would have a water rate of 17 pounds, and 1 per cent. on 17 pounds is different from 1 per cent. on 20 pounds.

Mr. Roberts read the following quotation from Lester G. French's book upon the steam turbine: "Comparing these figures with those of Table XVIII it seems probable that the reciprocating engine will, under exceptionally good conditions show a little better economy than the turbine when running at its most economical load, but that what we have called the 'average high-grade engine' appears to about equal the turbine in its rate of steam consumption at most economical loads."

The Westinghouse Paper

The third paper was one by J. R. Bibbins, of the Westinghouse Machine Company, on "Recent Developments in Steam-turbine Power-station Work."

The paper was written with special reference to the Spy Run station of the Fort

Wayne & Wabash Valley Traction Company. The following is a very full abstract of it:

If any one feature may be said to characterize recent engineering practice in turbine power-plant construction, it is that simplification of operating equipment which lowers investment cost, labor and up-keep and the possibility of service interruptions, the while preserving a degree of working economy commensurate to the service in view. The underlying object is, of course, the maximum commercial, rather than physical efficiency, and this applies as much to auxiliary as to principal generating practice. A very important factor contributing to this desired simplicity of plant, is compactness of arrangement such as permits the subdivision or grouping of related apparatus more or less on the unit principle. Thus, in many modern stations, each unit is served by a certain group of boilers and an independent set of auxiliaries, so that in the event of trouble, the damage may be entirely isolated. In one plant (Carville), all auxiliaries are motor-driven, and at starting all motors of a particular section "pick up" load with the main generators to which they are connected. Economizers are used for feed heating. In the case of the condenser, the old centralized plant has developed not only into individual units, but condensers located directly beneath the turbines. And, owing to the relative bulk of the surface type, this has again led to skeleton turbine foundations, and finally, to constructions of steel or reinforced concrete.

To what an extraordinary degree of compactness turbo-machinery has attained is evidenced by Fig. 3. Less than one-fourth of the horizontal Corliss, and less than one-third of the vertical engine, the turbine in larger sizes requires but 1/20-square foot per generator horsepower. This has further brought about radical changes in boiler-plant arrangement. In place of the familiar square power house, divided equally between parallel boilers and generating rooms, the latter now occupies barely one-third of the total, and boiler batteries are arranged at right angles to the turbine room to provide for the otherwise cramped boiler capacity without unduly lengthening either building or steam piping; for example, Carville station, Newcastle (Eng.); Gould street station, Baltimore; Commonwealth station, Chicago; Waterside station No. 2, New York City, etc. In many cases, the value and limitations of the site have even necessitated multiple-decked boiler rooms, such as Waterside No. 1 and No. 2; Lots Road station, Chelsea (London); Long Island station, Pennsylvania railroad, New York City; Kent Avenue station, Brooklyn, etc.

Another important development has taken place along lines calculated to foster heavy-peak and emergency overloads; in the generator, forced ventilation; in the turbine, auxiliary or secondary admission of steam to assist on overloads without detriment to the economy on normal loads; in the boiler plant, mechanical stokers; and mechanical draft auxiliaries to normal chimney draft. The equipment of such stations thus provides exceedingly valuable forcing capacity. Accordingly, an essential requisite of the modern turbine is rugged construction, even at the expense, to a certain degree, of fine economies, obtainable at best only under extremely favorable conditions, which are seldom obtained and never maintained.

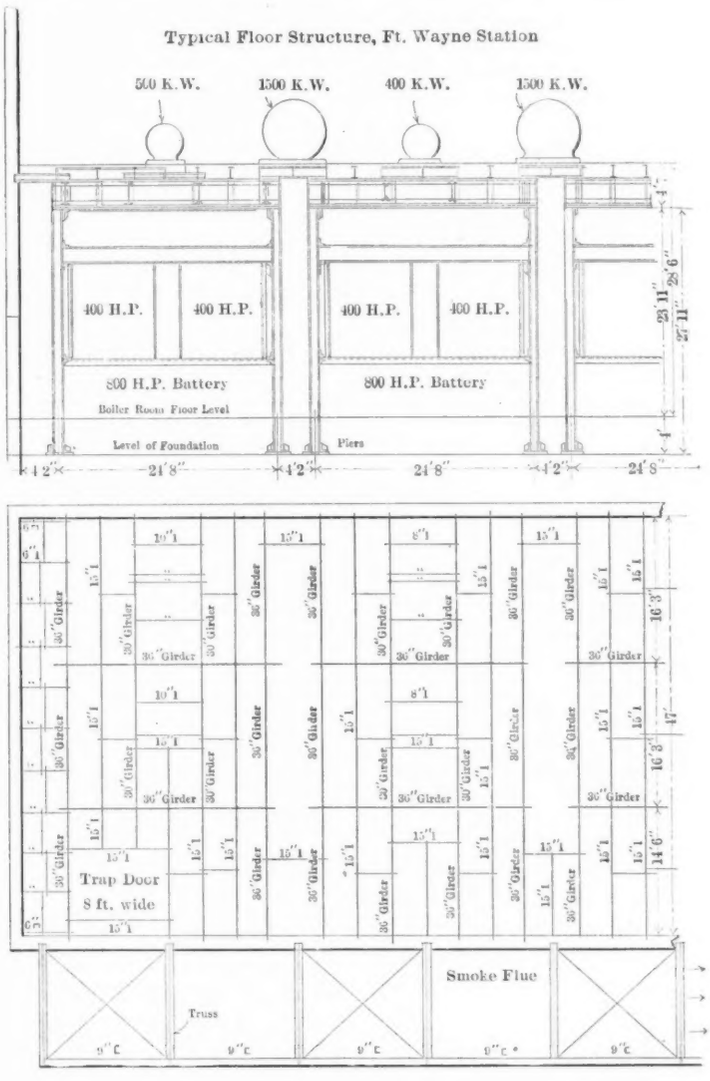


FIG. 7. DETAIL OF FLOOR STRUCTURE

Combined Service

A development of considerable importance, especially in the field of moderate-sized power properties, is the combination of services of different characters in a single central generating station—such, for instance, as interurban railway and central-station lighting. This, of course, has been common practice where same kind of current is distributed, but by no means general when the services have been kept distinct. A number of systems have been put into operation, or projected within recent years which embody this feature of combined service. Of these, the Fort Wayne system, later described, is typical. This system possesses at least one important advantage: the more effective working of boiler capacity. In the generating room, the two systems are independent electrically, unless interconnected through a frequency changer which, although complicating the equipment somewhat, might prove invaluable in emergencies. Steam, on the other hand, is generated to meet the average load of both systems, irrespective of frequency. This will be clear from a study of load curves, Fig. 4, and the analyses, Table 1—data taken from an actual system, such as the Fort Wayne, and of about the same size.

The curves represent a Saturday load only, but are typical of other days. Note first the relative loading of generating units. For the lighting load, yielding a true load factor of 39 per cent., which is high, the average unit load is but 34.6 per cent. of the rated capacity. But, the railway gives a unit load of 67.8 per cent.

rating; and combined the plant operates at an average unit-load factor of 50 per cent., which is also high, considering the relative size of the units, 1000 kilowatts. This problem, of course, reduces to the question—whether two small plants can be operated at respective unit-load factors of 34 per cent. and 68 per cent. more efficiently than a combined plant of 50 per cent. unit-load factor—undoubtedly so. Fig. 4 shows in a general way how well the systems superpose. Thus, lighting load at (*A*) makes up for the early morning deficiency in railway load. During the day, the situation is reversed as at (*B*). In the evening, the railway load usually falls off as the lighting load increases (*C*).

This question is, however, best answered by Fig. 5 representing the variation of cost and efficiency with station-load factor for this same system. It is notable that an increase in the *lower* load factor brings the *greatest* increase in efficiency. From 25 to 30 per cent., the decrease in operating cost was 15.7 per cent.; from 30 to 35 per cent., 9 per cent. This shows that considerably more is gained by increasing the lighting factor than is lost by decreasing the railway, which, together with the decreased boiler-standby losses and the good effect of centralization, represents the net results of the combination of operating systems. In the one case, 3.1 times the average day boiler capacity is necessary to carry the lighting peak; for the entire plant, but 1.8 per cent. This not only lowers standby losses, but also materially reduces the boiler capacity necessary for a given turbine output. Thus, at Fort Wayne, there is installed but slightly over 0.5 boiler horse-power per kilowatt, whereas the usual allotment is 0.75 boiler horse-power and more.

The Fort Wayne Station

The new electric service station of the Fort Wayne & Wabash Valley Traction Company at Fort Wayne, Ind., executed along decidedly novel lines, presents an unusually interesting study of the engineering possibilities of turbine-plant construction.

Like many other similarly situated railway concerns, this company serves both traction and lighting systems from a central power station, and its lighting business has assumed such proportions that nearly one-half of the new power station is devoted to 60-cycle lighting equipment—the remainder to 25-cycle equipment for power purposes. The site chosen parallels a small stream—St. Joseph's river—from which the water supply is drawn for both feed and condenser purposes:

The principal features of the station may be summarized as follows:

(1) A two-story, rectangular brick structure with side wings for the accommodation of auxiliary apparatus, coal bunker, machine shop and stores.

(2) Generating machinery on second floor over boilers.

(3) Structural foundations with concrete-arch floor construction.

(4) Independent barometric jet condenser—moderate vacuum.

(5) Gravity conduit system for cooling water.

(6) Independent, direct-driven exciters—common bus for each system.

(7) Steam piping—simple, short and direct, with continuous upward slope from boiler nozzle to turbine throttle.

(8) Sufficient superheater surface to maintain dryness, or moderate superheat at beginning of expansion in the turbines—100 to 125 degrees at the boiler.

(9) Mechanical stoking with gravity fuel feed.

(11) 6000-ton (two months') coal storage, served by gantry crane.

(12) Steam-driven auxiliaries for feed heating.

(13) System of forced ventilation for turbo-generators.

(14) Fireproof transformer compartments, with transformers mounted on rolling trucks to facilitate removal.

(15) Remote control oil circuit-breakers with time-limit overload relays.

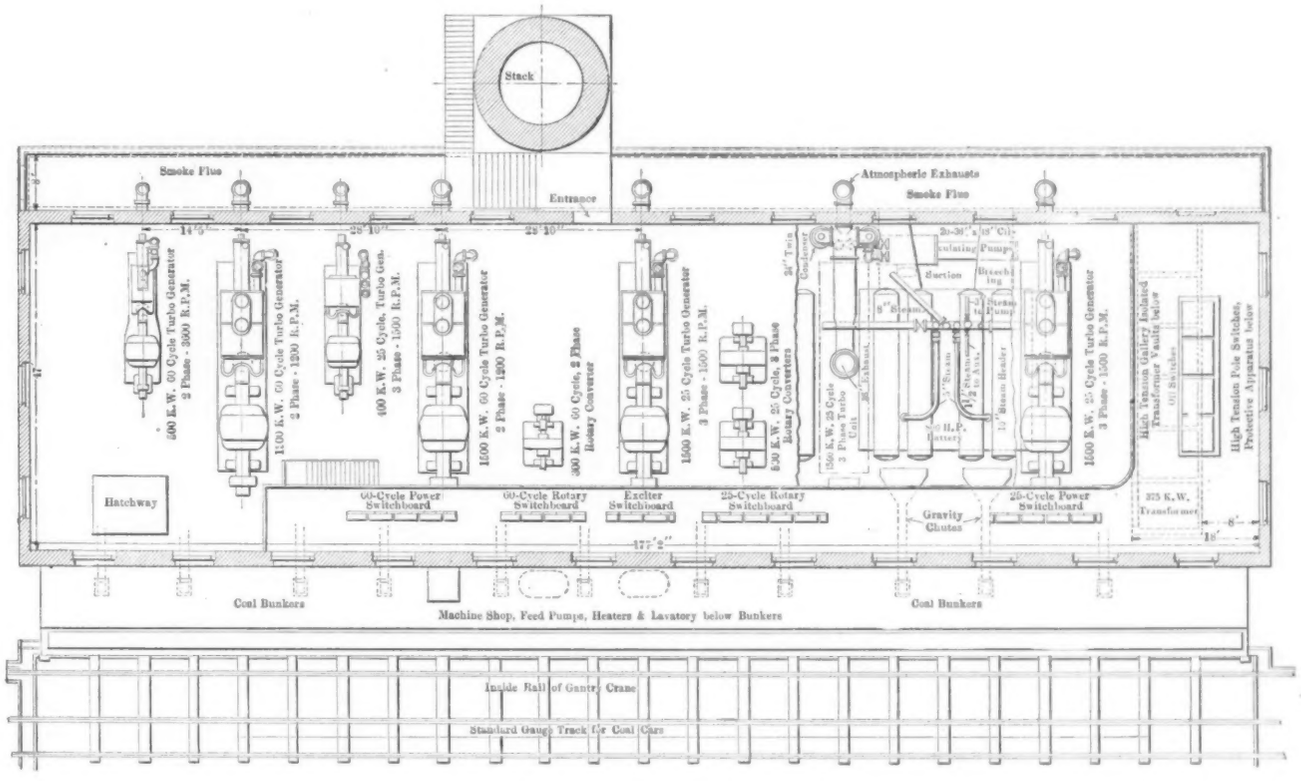


FIG. 8. GENERAL PLAN OF STATION

Essentially the station represents an attempt to produce a power property that will show to best advantage in the balance sheet with a medium-priced coal—one in which the absence of engineering "frills" for securing the highest efficiency is compensated for by lower capital cost. This should be borne in mind in the discussion of the operating results later noted.

DATA ON POWER HOUSE

Dimensions of building, ground-floor plan (47 ft. by 177 ft. 2 in.)	8,340 sq. ft.
Condenser room (9 ft. 6 in. by 177 ft. 2 in.)	.....
Pump room (8 ft. by 177 ft. 2 in.)	1,419 sq. ft.
Heater and pump room (12 ft. 6 in. by 173 ft.) ..	2,160 sq. ft.
Total area of power house, single-deck basis	20,273 sq. ft.

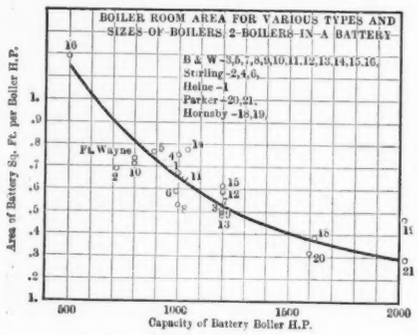


FIG. 9. BOILER-ROOM AREA

Hight boiler room, 28 ft. 6 in.; turbine room to crane rail, 21 ft. 7 in.	
Present capacity, 60-cycle, 3500 kw.; 25-cycle, 3500 kw.	7,000 kw.
Ultimate capacity, ...	8,500 kw.
Ultimate capacity, entire plant max. rated overload.	12,750 kw.
Present sub-station capacity, 1300 kw. ultimate.	2,600 kw.
Present boiler capacity, 10 400-h.p.	4,000 bo. h.p.
Ultimate boiler capacity, 12 400-h.p.	4,800 bo. h.p.

RELATIVE AREA

Station, ground-floor plan	1.39	sq.ft. per kw. ult.
Station, single-floor plan	2.39	sq.ft. per kw. ult.
Operating room (floor plan)	0.98	sq.ft. per kw. ult.
Operating room (exc. high-tension and sub-station equipment	0.722	sq.ft. per kw. ult.
Boiler room (net floor plan)	1.74	sq.ft. per bo. h.p.
Total boiler room and bunker	2.19	sq.ft. per bo. h.p.
Boiler settings (24 ft. 8 in. by 23 ft. 5 in.)	0.725	sq.ft. per bo. h.p.
Relative boiler capacity, ultimate ..	0.56	bo. h.p. per kw.

As previously pointed out, the building construction in turbine power plants is largely influenced by arrangement of boiler equipment. In this case, it was apparent that a somewhat lower boiler capacity than usual would be required for the combined service. For moderate-sized units, a well-equipped boiler room requires from 2 to 2.5 square feet per boiler horse-power, in some extremely compact arrangements requiring as low as 1.5 square feet per boiler horse-power. The Fort Wayne arrangement works out 1.75 square feet per boiler horse-power. Assuming a capacity ratio of 0.6 boiler horse-power per kilowatt, the floor area then works out slightly over one square foot per kilowatt for boiler room alone.

Now, for a fairly compact generating room in a station of this size, from 0.75 to 1.15 square feet per kilowatt are required, as will be apparent from the comparative data on turbine stations, later noted. But, for the Fort Wayne plant, some provision had to be made for the accommodation of direct-current sub-station apparatus. Assuming one square foot per kilowatt as a reasonable area, we find that this practically coincides with the above boiler-room area. The designer thus had two alternatives: First, a double-decked power station, or second, a building of twice the area with two equal-sized operating rooms in parallel and under one roof, which arrangement would be preferable. From an investment standpoint, it is hardly open to question. As it stands, the building cost about $12.50 per kilowatt, including additions, which is by no means excessive.

Inseparable from this building arrangement, is the question of structural foundations which are entirely justifiable in the case of the steam turbine owing to the absence of cyclical movement arising from unbalanced parts, requiring in the case of low-speed reciprocating engines the most rigid foundations. Fig. 6 shows a cross-section of the turbine and condenser arrangement relative to foundation. Here reinforced concrete columns 20 feet in hight and 10 to 15 inches in section support the entire turbine floor, as shown in the drawing. These machines are 1500 kilowatts capacity, spaced 14-foot centers.

The floor structure of the Fort Wayne station is shown in detail in Fig. 7. It consists of individual pairs of transverse plate girders extending across the building under each turbine bed-plate. Short cross girders serve to tie the longitudinal

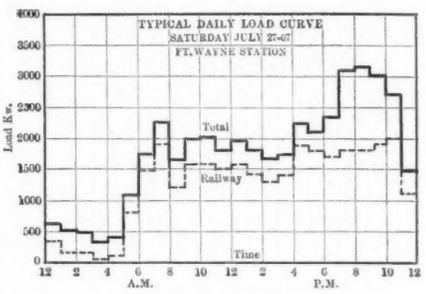


FIG. 11. TYPICAL DAILY LOAD CURVE

girders together at column intersections, the whole forming "bents" or cradles between the several generating units. Box columns divide the building width into practically three equal spans, these columns rising between the several boiler batteries. Thus the weight of the generating machinery is distributed between two building walls and two rows of columns. Only in the case of the smaller machines and rotaries does any of the weight fall upon the areas intervening between columns. In order to insure even settling, the precaution was taken of carrying footings for both columns down to practically the same level so as to encounter homogeneous strata.

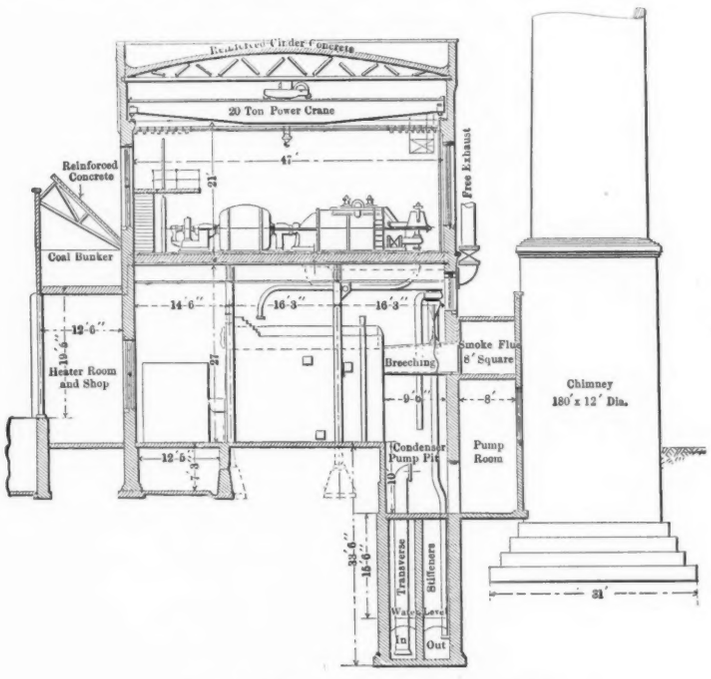


FIG. 10. SECTIONAL VIEW OF STATION

Boiler Plant

It is apparent from Fig. 7 that the location of the large turbines was chosen so as to accommodate under each floor "bent" a single battery of boilers. With the small boiler units chosen, this of course provides a larger turbine room above than is necessary; but, by utilizing the excess floor space for sub-station apparatus, this disadvantage is largely overcome. The floor plan drawing, Fig. 8, shows to what advantage the space has been utilized.

It is noteworthy here that with larger boiler units, a far more compact arrangement would be possible with little increase in floor span between batteries. Fig. 9 shows clearly the relative reduction in boiler area for units ranging from 500 to 2000 horse-power. The majority of these are the standard B. & W. type setting, with single tiers of tubes. In case of a special demand for stations of the Fort Wayne type, it is quite possible that a boiler could be obtained giving a much narrower battery than with the standard setting, but with ample grate surface.

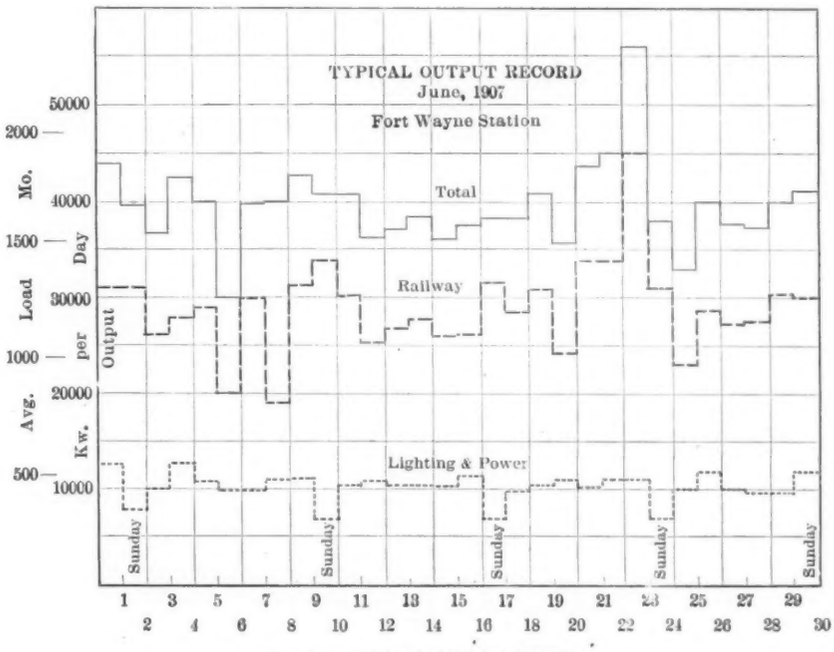


FIG. 12. TYPICAL OUTPUT RECORD

This relative disposition of boilers and turbines evidently permits of the simplest form of piping. Strictly on the unit principle, this would involve but two bends, as shown in the cross-sectional drawing, Fig. 10. The addition of an equalizing header running the length of the building, then, complicates the piping only to the extent of extra valves, fittings and hangers, resulting in:

(1) Most direct path of steam from boiler to turbine.

(2) Equalizing connection to compensate for variations in the rate of steaming of boilers in service.

(3) Provision for most convenient distribution of boiler capacity to carry any load.

(4) A cost of $2.50 per kilowatt for steam piping, complete.

In the normal operation of the plant, effort is made to keep those boilers in service nearest to the turbines in operation, thus giving the minimum distance of steam flow. When occasion arises, the plant may be operated on the unit system, valves in the header between the various risers being supplied for this purpose.

Superheaters were installed principally for the purpose of insuring thoroughly dry steam at the beginning of expansion in the turbine. Although moisture in the steam system is not encountered in normal operation, the precaution was taken of delivering steam from the boilers underneath and discharging it above the header, so that a continuous draining is provided from turbine throttle back to boiler. This is likely to be an advantage in starting a section of the plant that has stood idle for a time.

In the arrangement of the breeching, the main smoke flue might have been run inside the boiler-room walls, thus avoiding the breech connection shown in Fig. 10. This, however, would have necessitated locating the condensers outside of the building. With the present arrangement, a ten-foot space back of the boilers is ample for all condensing apparatus, and the space under the external smoke flue is utilized as additional boiler-room area for small auxiliaries, oil filters, etc.

Superheated steam is provided direct from the main to all principal auxiliaries in the plant, avoiding an auxiliary steam main. The supply pipes of the auxiliaries are connected directly into the steam main at different points. Thus, boiler feed-pumps are connected in duplicate to opposite sections of the steam main, each of which is supplied by at least four boilers. Similarly, condenser pumps are connected to the same section of the main as the turbines which they serve. (See Fig. 8.) If a turbine unit is disabled, the pumps will not, of course, be needed.

The absence of economizers will be noted. These were not considered necessary with coal at $2 to $2.50 per ton. For feed heating, auxiliary exhaust steam is entirely relied upon—all boiler, service and condenser pumps, also fan and stoker engines contributing heat through the medium of open heaters. Exciters are direct-driven, as later noted. Nevertheless, a feed temperature of 160 to 180 degrees is obtainable during the day, and 200 degrees at night. This feed is drawn from the hot condenser discharge tunnel and delivered to an elevated tank, which provides a static head on the heaters and is of sufficient capacity to supply the plant for three hours at full load. Similarly the heaters are elevated a few feet to insure a positive lift of feed-pump valves. With this feed system, boiler cleaning is not necessary oftener than at monthly intervals.

Mechanical stoking was adopted not only to minimize labor cost, but also to provide ample forcing capacity for peak loads or emergencies. With Hocking Valley screenings, three men can handle without difficulty, ten boilers, or 1330 boiler horse-power each. Hand-firing for the same capacity would require ten firemen and two water-tenders, or 400 boiler horse-power per fireman, a reduction of 60 per cent. Present boiler-room labor, averaging $11.75 per 12-hour shift, would be increased to about $28 per shift, providing 12-hour shifts could be maintained.

Condenser Plant

The character of river water had, of course, an important bearing on the design of the condenser system. Although carrying considerable sediment at times, the water is extremely soft and develops no hard scale even after many weeks of continuous running. This annulled the principal advantage of the surface condenser, viz, return of pure exhaust steam for feed-water. The 25-foot difference in level between the ground floor and low water, made one of two condenser systems imperative:

(a) Surface condenser with continuous pipe loop (balanced water column), with power-driven circulating pumps to overcome fluid friction.

(b) Barometric jet condensers mounted near the level of turbine exhausts with tail pipes extending downward to the normal river level, with power-driven circulating pump to overcome excess barometric head.

With the former, dry-vacuum pumps would be imperative in order to prevent the condensers from becoming air-bound, or losing their vacuum altogether through air leaks in the water system, thus adding

another auxiliary. Moreover, the surface type of plant is extremely bulky and would have seriously interfered with the "double-decked" lay-out.

On the other hand, the barometric type fits particularly well into the scheme. The condenser head may be suspended beneath the turbine where its most bulky part is out of the way. The tail pipes may then be carried down at any angle or turn sufficient to clear necessary obstructions. Thus, the 9.5-foot areaway which would ordinarily be provided in the rear of the boilers is conveniently utilized as operating space. With the arrangement employed, as shown in Figs. 8 and 10, a difference of about 47 feet exists between the condenser head and low-water level. This, however, does not interfere with the operation of the condensers, as a partial void simply results in the upper part of the barometric column.

The use of twin condenser units permits the use of less bulky apparatus, and also makes it possible, in the event of the disablement of one side, to continue operation on the other with reduced vacuum. Long-stroke reciprocating pumps were chosen for this purpose instead of high-speed centrifugal pumps, as being best suited to the high lift—sixteen feet. With this type of pump, a small air chamber will suffice to carry over the moment of reversal without any "dip" in vacuum, which would otherwise accompany the non-uniform flow of injection water. This equipment without dry-vacuum pumps yields a vacuum during warm weather of about 26.5 to 27 inches at full load (referred to 30-inch barometer). Its simplicity and ease of up-keep are apparent, and the cost low—about $2.50 per kilowatt, including pumps and piping, but no tunnel work.

Water is conducted to and from a screen house on the river bank entirely by gravity through a double-duct concrete conduit. At the river a double screen prevents debris from entering the intake, which is at right angles to the current, while the discharge is down-stream. This conduit system, of course, necessitated considerable excavation in the rear of the boilers. The two retaining walls were then reinforced at intervals by transverse stiffener arches sprung across the pit.

Coal Storage and Handling

The Fort Wayne plant uses normally about 100 tons of coal per day. In the provision for coal storage, an elevated bunker of relatively small capacity (400 tons) fulfils all requirements for gravity feed. Even this would tide the plant over a period of at least three days in case of failure of coal-handling apparatus. The main storage yard will contain about 6000 tons, sufficient for two months' supply, but only about 4000 tons is ordinarly held in stock, except in case of impending fuel shortage. A Gantry crane serves this storage yard. It combines the functions of unloader, crusher, elevator and distributor. Its efficiency is attested by the fact that while its normal capacity is considered to be one 50-ton car per hour, the operators have unloaded a 40-ton car in sixteen minutes, and a maximum of eleven cars (500 tons) in a short working day. The crane is electrically operated from a single controller tower by one man.

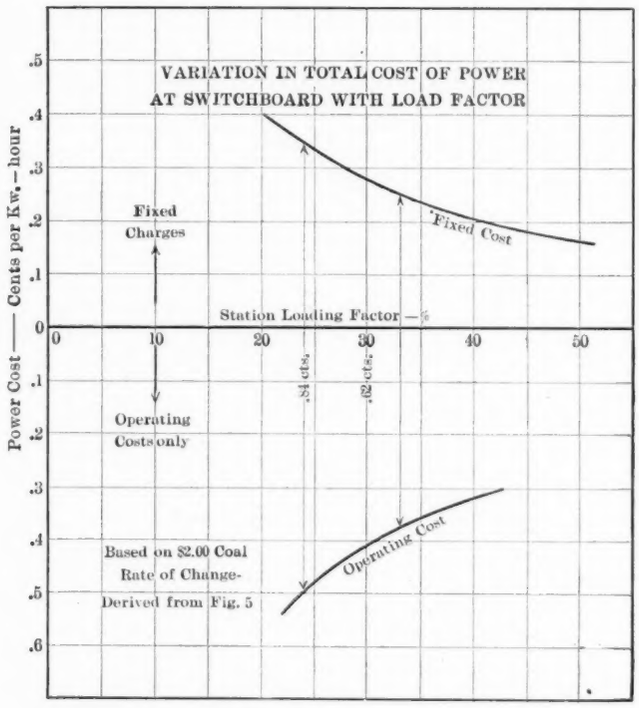


FIG. 13. VARIATION IN POWER COST

Operation

Owing to the brief period in which the Spy Run station has been in operation, it is not possible to analyze very accurately either the operating efficiency or the operating costs. Moreover, considerable extensions are under way, which will materially increase the loading factor of the station. During the month of June, the Fort Wayne station turned out 24 per cent. of its rated output. Fig. 11 shows a typical daily load for Saturday, the loading factor from which is about 33 per cent. of the 24-hour capacity. The dotted line represents the railway load alone, and for uniformity could hardly be improved. Combined with the lighting, the station is still loaded very efficiently, with the result that while there is but little advantage from the traction standpoint, by combined operation the lighting system is greatly improved. Here arises the greatest gain from the combined system. Following these load characteristics through the month, we find little change in the relative load from day to day. Fig. 12 shows the lighting, traction and total load for the month of June. It is noticeable that the regular drop in the Sunday lighting load is usually made up by the increased Sunday railway load, which will generally be the case on all holidays.

Now, taking this month as a basis, we may predict with some degree of certainty, the change in operating efficiency and cost with the improved loading factor, by applying data from the similarly equipped and operated system previously noted in Figs. 4 and 5. These data were obtained at a time when the system had developed to just about the same extent as the present Fort Wayne system. Assuming the average loading factor of a normal lighting system to be in the neighborhood of 23 per cent., these data show a reduction in operating cost of nearly 30 per cent. (to 0.35 cent per kilowatt-hour) by increasing the loading factor to 33 per cent. of the output capacity of the station. Owing to extensions in city and suburban traction, a loading factor of 40 per cent., at least, may be expected at Fort Wayne. It is, therefore, evident that an extremely low power cost may be anticipated. How much the various mechanical contrivances around the station have contributed to the low cost is shown by the fact that the labor cost for the entire station, including coal handling, averages but $34.60 per 12-hour shift, equivalent to 0.12 cent per kilowatt-hour at 33.5 per cent. loading factor, which is considerably lower than the usual figure in steam plants. Even this could be reduced about 10 per cent. at the present, as several men, in training for outside service, are now maintained upon the regular station payroll.

Costs

In the final analyses of the ultimate cost of power, fixed or capital costs, of course, have an important bearing, and it is in this regard that the type of station

exemplified in that previously described exerts the strongest influence. In the preceding discussion, it has been the object to show wherein the double-decked station has made the greatest advance along engineering lines. Owing to the absence of many refinements, it is evident that the maximum possible efficiency could hardly be obtained. In compensation, we should look for a considerable reduction in the capital charges in order to bring the total cost of the power generated to as low a point as would result from the use of a more efficient plant. This proves to be the case with the Fort Wayne station.

Analyses of the total power costs from modern steam plants of 5000 to 10,000 kilowatts capacity show that the capital costs, including interest and depreciation, amount to about 50 per cent. of the total. For such high-grade stations, with thoroughly modern equipment, we should expect an investment cost of from $150 per kilowatt in the smaller, down to $100 per kilowatt in the larger sizes. In a few very large stations the investment cost has been less than $100 per kilowatt, but for stations under 10,000 kilowatts it very rarely occurs that the cost is below the above figure. The Fort Wayne station is thus unique in having set a new standard for power-station cost which may well be emulated in cases where turbine machinery is applicable. Table 3 shows the cost of the complete station, exclusive of substation apparatus, but including main line transformers—a total of $66.25 per kilowatt generating capacity. In this summary, the building cost is naturally high, owing to the large amount of structural material necessary. On the other hand, boiler and condenser costs are extremely low for reasons previously set forth.

Using as a basis these costs, and the rate of variation with loading factor already shown in curve form, Fig. 5, the ultimate total cost of power at different loading factors may now be predicted; in other words, the total financial result of station operation. Fig. 13 has been prepared along these lines. Fixed charges are dealt with entirely above the horizontal line, and operating costs below. The total power cost, at a given loading factor, is then represented by the total vertical distance between the two outer curves. These fixed costs are based upon the following assumptions:

(a) Bond interest and taxes	7 per cent.
(b) Sinking fund, equivalent to 6.43 per cent depreciation*	4.2 per cent.
(c) Total fixed charges on capital cost	11.2 per cent.

From these curves, Fig. 13, the total cost of power at the present station loading factor, 24 per cent., is 79 cents per kilowatt-hour. At 33 per cent. loading factor, the total cost would be 0.57 cent per kilowatt-hour, and at a possible loading factor of 50 per cent., 0.41 cent per kilowatt-hour. This the author ventures, is a result which it will be difficult to duplicate in any station of expensive construction burning the medium grade of bituminous coal at a cost in the neighborhood of $2.25 per ton. It is the ultimate result that proves the correctness of the engineering principles involved in the design of the station.

*Depreciation determined by summing the depreciation on the several parts of the plant as follows: Building, 3 per cent.; boiler plant and coal-handling apparatus, 10 per cent.; condensing plant, 6 per cent.; generating plant, 7.5 per cent.; general average, 6.43 per cent.

A Year's Experience with Gas Engines

By Paul Winsor

The Boston Elevated Railway Company has been operating two gas-power stations a little more than a year, one of which is designated the Somerville station. This station is equipped with a pair of Loomis-Pettibone pressure producers for burning bituminous coal, two two-cylinder-opposed Crossley engines of 600 brake horse-power each, and two Crocker-Wheeler direct-current generators, with the usual gas and electric auxiliary equipment. At the recent meeting of the American Street and Interurban Railway Engineering Association the results of the past year's experience with this plant were presented in a paper by Paul Winsor, chief engineer of motive power and rolling stock for the railway company. The following is an abstract of Mr. Winsor's paper:

The plant was started in May, 1906, and since then has given continuous, reliable and satisfactory service. There have been no shut-downs, no accidents and no failures. The fuel has been soft coal, the same as used in our steam stations, mostly run-of-mine Pocahontas. The economic results are shown in the accompanying table. These are the results from actual service and include all the fuel used for power, heating, etc., and the auditor's usual 1 per cent. to make his books balance.

Water

We have used a great deal of water for scrubbing the gas and for cooling purposes. The average amount has been 281 pounds per kilowatt-hour. When we bought this water, as we did for a few months, our water cost about twice as much as our coal. We have been, since November 21, 1906, pumping this from a very dirty brook by means of 2-stage centrifugal pumps, electric driven; and filtering through a pressure sand filter. This outfit has been entirely satisfactory and has given us no trouble. The suction lift is 12 feet and the pressure at the pumps 30 pounds.

The discharge of water from the gas scrubbers is very dirty, being full of floating lampblack, and is altogether too black to put back into our dirty brook. A sand filter basin, 246⅔ square feet in area and tile under-drained, removes all the lampblack, so that we are turning back into the brook cleaner water than we take out

Ignition

Our ignition current is from 14-volt motor generators and a floating storage battery and we have no trouble with the outfit. The igniters are make-and-break, two to each cylinder. These igniters had originally platinum tips, which cost a great deal and gave considerable trouble. We have been running now four months without any platinum and with less trouble.

Back-fires and Pre-ignitions

During the first months back-fires and pre-ignitions were much too frequent, occurring almost every day. Lowering the compression on one of the cylinders, changes in the igniters, and experience have reduced these troubles, so that we now go two or three weeks without a single one.

Reliability

This plant has proved absolutely reliable. It can be put into service any time in less than five minutes—much quicker than can our steam plants. It can carry good loads and do it continuously. Each unit has carried 450 kilowatts (652 brake horse-power) for an hour, with swings to 495 kilowatts (717 brake horse-power).

Somerville Power Station, Boston Elevated Railway Company Power. Date, January, 1907, to August, 1907.

	Jan.	Feb.	March.	April.	May.	June.	July.	Total.	Average.
Kilowatt-hours	204,080	175,200	192,250	202,870	118,640	35,770	60,170	988,980	.....
Total pounds coal, including coke	391,223	364,817	405,050	401,150	234,705	90,991	124,452	2,012,388	.....
Pounds coal per kilowatt-hour	1.917	2.081	2.120	1.975	1.979	2.542	2.065	.....	2.034
Pounds coal per brake horse-power-hour	1.322	1.436	1.426	1.363	1.365	1.755	1.425	.....	1.404
Station load factor based on 16 hours per day and 7 days per week	58.8%	55.9%	55.3%	60.4%	34.2%	10.6%	17.3%	.....	41.6%
Engine load factor	84.2%	86.0%	87.4%	82.3%	78.3%	73.3%	82.8%	.....	83.3%
Generator load factor	99.3%	101.3%	103.0%	97.1%	92.4%	86.5%	97.7%	.....	98.35%

Efficiency

For the first seven months of this year this plant used 2.034 pounds of coal per kilowatt-hour, while our steam plants averaged 3.477 pounds per kilowatt-hour —a saving of 41.5 per cent. One of our smaller steam plants, containing three 200-kilowatt compound condensing engines, used 4.414 pounds per kilowatt-hour; this gas station used only 46.1 per cent. as much.

Conclusions

Personally, I believe that a gas-engine plant, making its own producer gas, will operate at least as reliably as a steam plant and will use from 30 to 60 per cent. less fuel, depending principally on the size of the steam plant.

The drawbacks to the gas plant are, in my mind, the first cost, approximating $200 per kilowatt when rated so as to have a 33⅓ per cent. overload capacity, and the small size of units—the largest gas engine now built being only of about 3000 kilowatt capacity.

A Peculiar Gas-engine Wreck

The accompanying photographs show the principal results of a gas-engine accident of very unusual character which occurred recently in the factory of D. S. Plumb, Newark, N. J. The engine broke its base in two and the rear half turned a back somersault, leaving the front half on the foundation as shown in Fig. 3. The cause of the wreck is uncertain; it was undoubtedly due either to an explosion of mixture inside the base or to the premature explosion of an extremely good mixture in the cylinder. Fortunately, no one was injured.

The engine was a single-cylinder White & Middleton gas engine of 12 inches bore, working on the four-stroke cycle and running on illuminating gas supplied from the Public Service mains. It was of the hit-and-miss type, with an automatic main admission valve between the mixing chamber and the cylinder and a mechanically operated gas valve between the gas-supply pipe and the mixing chamber. The air supply was drawn into the mixing valve from the interior of the base. Ignition was effected by means of a Bunsen tube, without any timing valve, the tube being designed with the idea that the fresh mixture should be protected from ignition by the spent gases remaining in the tube, until compression forced the mixture up into the tube far enough to reach the flame.

The engine was a chronic back-firer. It would back-fire violently at times, until the proportion of air to gas was changed by adjusting the mixing valve; then it would run along quietly until some change in operating conditions occurred, when the back-firing would be resumed.

On the morning of the accident, the engine began to back-fire as soon as it was started up. After a few moments, the man in charge of it shut it down to look over the valves and gear, and found a collar loose on the gas-valve push-rod. This was set up tight in place and the engine started up again. It ran without any indication of trouble for a revolution or so, and just as the engineer closed the compression-relief valve and stepped from behind the cylinder, the crash came, the cylinder and rear half of the base being thrown over backward and just grazing his arm. He, as well as the two men at the fly-wheel who turned the engine over to start up, stated that there was no explosion other than the power explosions in the cylinder. If their impression of the occurrence is accurate, the accident was doubtless due to the firing of an unusually good mixture in the cylinder at just the moment when the crank was on the dead center and the piston could not relieve the pressure.

This hypothesis seems reasonable in view of the character of the break in the base walls. By reference to Fig. 2, it may be seen that almost all of the fracture on one side and a good portion on the other was old, as indicated by the dark, oil-soaked appearance of the metal.

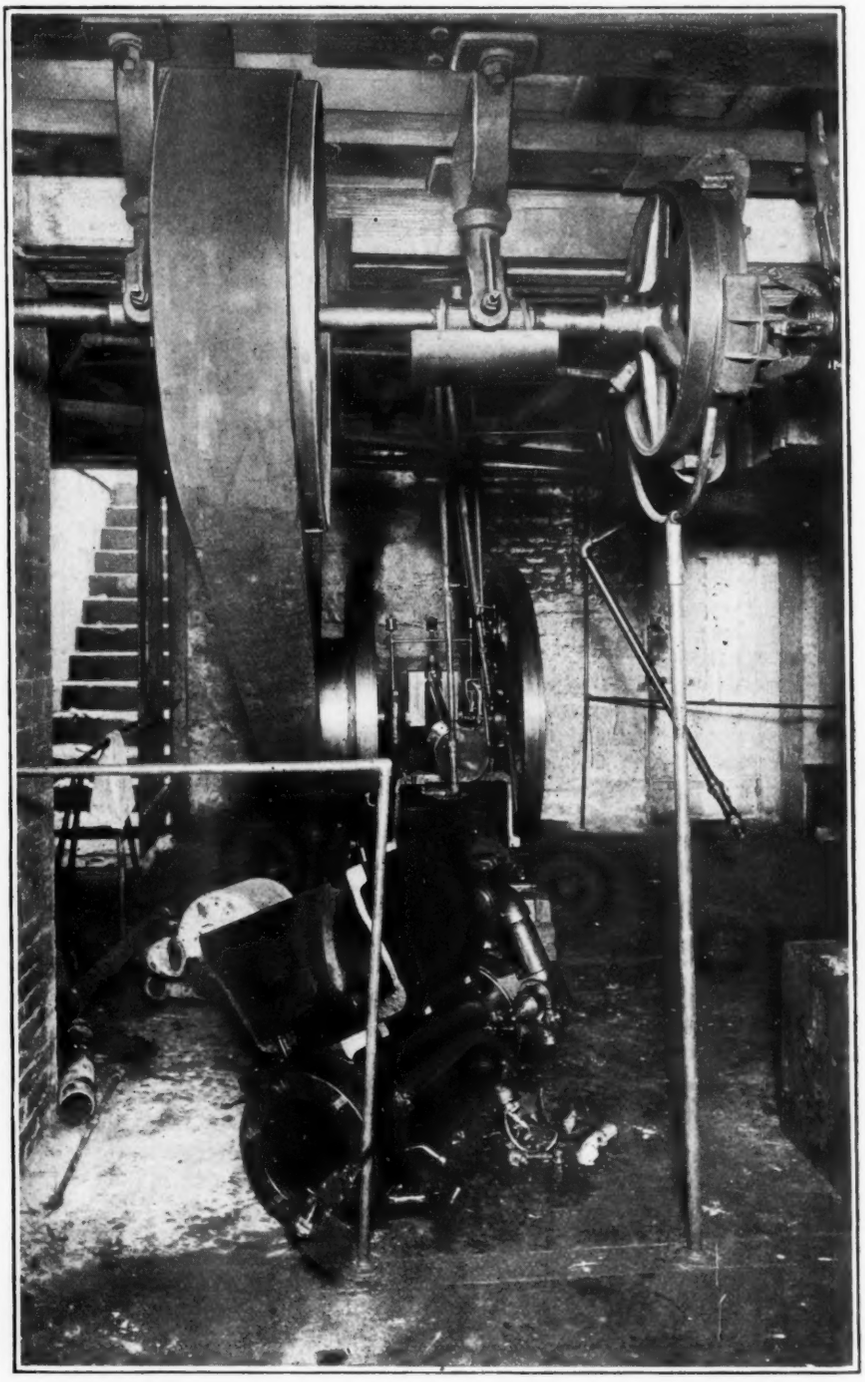


FIG. 1. VIEW OF THE WRECK FROM THE REAR

FIG. 2. A CLEARER VIEW OF THE BASE FRACTURE

The white part of the break was clearly that which occurred at the time of this accident. This would explain why the base instead of the crank-shaft was broken if the accident was caused by a strong explosion in the cylinder when the crank was at the dead-center point of its travel.

On the other hand, the gas-admission valve had not been working properly, as indicated by the loose collar on the push-rod, and the engine had been back-firing. It is conceivable, therefore, that gas had leaked into the base and formed an explosive mixture which was ignited by a back-fire into the intake pipe, and that in the crash of the wreck and the excitement of the occasion the men did not realize that there was an explosion.

Fig. 1 is a view of the wreck taken from a point directly behind the engine, and shows that while the front half of the engine remained on the foundation, it was slewed around a trifle out of line That the part of it next to the break was thrown upward and dropped back on the foundation was indicated by the fact that the surface of the foundation was crushed out of shape for some distance from the break toward the forward end. This would fit in with the theory of a base explosion, but the fact that the rear half of the engine was thrown over backward, breaking off the rear holding-down flange, indicates that the disrupting force was horizontal and near the cylinder plane rather than in the base.

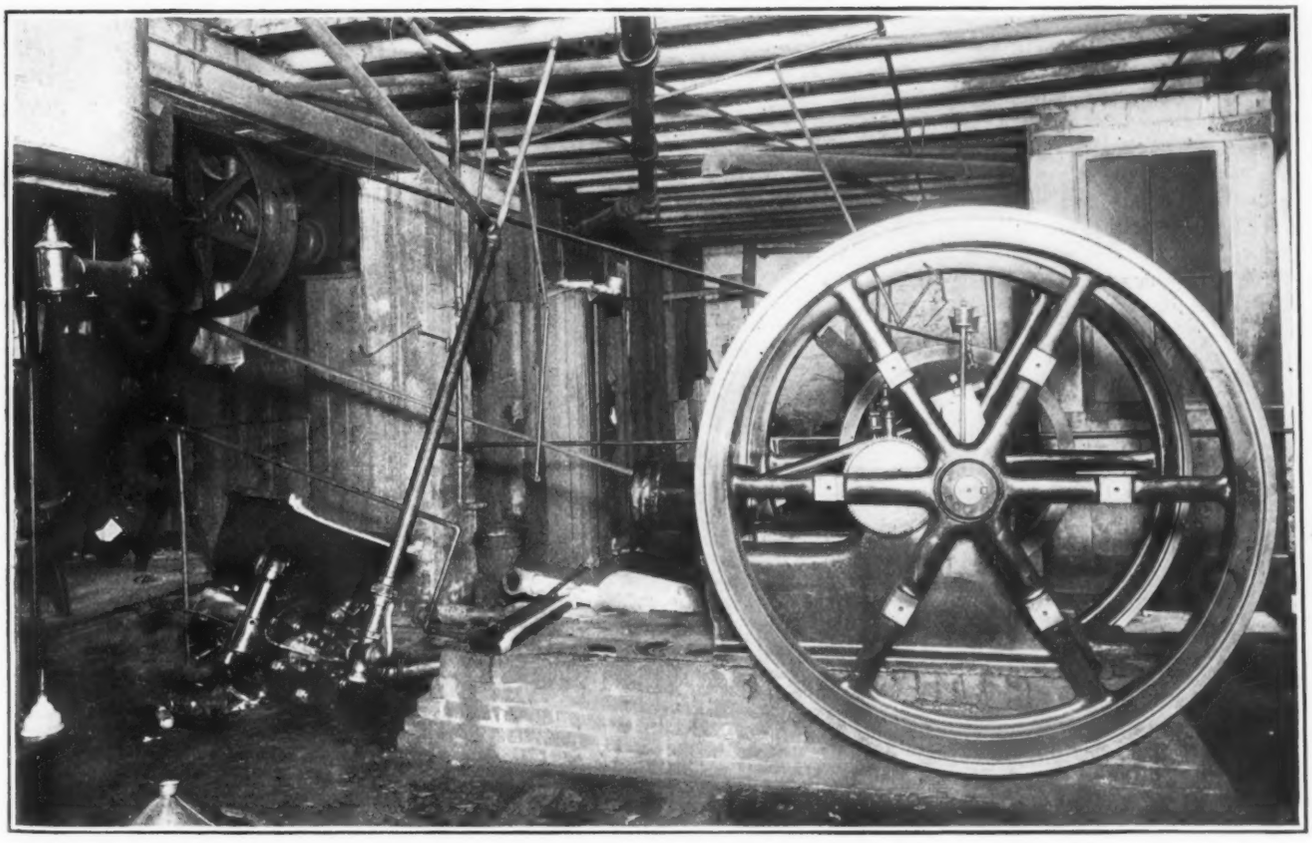


FIG. 3. VIEW OF THE WRECKED GAS ENGINE TAKEN IMMEDIATELY AFTER THE ACCIDENT

Application of the Entropy Diagram

Its Use Made Plain, as a Means to Compute Available Work or to Obtain a Clear Idea of Any Kind of Action in or upon Steam

BY PROF. SIDNEY A. REEVE

The article on "The Transformation of Heat into Work," in the November number, concluded with the computation of the cycle efficiency of a perfect steam engine using dry saturated steam. In practice, however, the steam is seldom dry. If the steam be wet its action is given by the cycle *a B F G* of Fig. 1 herewith. The work available from one pound of steam, and the efficiency of action, are computed much as before. Suppose that the steam is 20 per cent. wet. Then vaporization along *B D* has not been complete, but stops at *F*. This point must be four-fifths of the way from *B* to *D*, and the volume of steam formed and the heat absorbed are four-fifths of those values for *B D*. According to this, $B F = \frac{4}{5} \times 1.0896 = 0.8717$, and $a G = 0.4906 - 0.3126 + 0.8717 = 1.0497$. The heat supplied to each pound of feed-water, in order to turn it into wet steam, is the area beneath $a B F = 131 + (\frac{4}{5} \times 873.7) = 830$ B.t.u.

The heat left in the uncondensed exhaust, after the work has been done along *F G*, is the rectangle *b a G g*. Its hight is 673 degrees. Its width *a G* has just been computed as 1.0497. Therefore its area is $1.0497 \times 673 = 706.5$ B.t.u. The work done must be the difference between the heat put in and that left after the job is done, or $830 - 706.5 = 123.5$ B.t.u. = 96,083 foot-pounds per pound of steam used. The efficiency is $123.5 \div 830 = 14.88$ per cent.

But the efficiency when using dry steam was $151.9 \div 1004.7 = 15.12$ per cent. Apparently, the 20 per cent. of water in the steam has dropped the ideal efficiency only from 15.12 to 14.88. The actual harm due to wet steam is much greater than this. Moisture in an engine cylinder is like a clown in a gang of men: it interferes with the work of the more industrious portions more than its own idleness would lead one to expect.

Next, what are the weight and volume of steam formed by these processes? How much steam is developed by the boiler explosion *B C*? The entropy *a C* was found to be 0.1780. This is the excess of entropy in the steam and water, after explosion, over that of all-water at the same temperature, at *a*. Now the entropy involved in the complete vaporization of the pound of water under atmospheric pressure, or the distance *a c*, is known from the steam tables as 1.4349 (or it may be computed by dividing the latent heat at 212 degrees, or the area *b a e f*, by 673, the hight *b a*). Therefore the *steam weight* at *C* must be $0.1780 \div 1.4349 = 0.124$ pound per pound of hot water exploded.

The *steam volume* at *C* is 0.124×26.62 (which last is the volume of one pound of steam at 212 degrees, from the steam tables) = 3.30 cubic feet. Similarly, at *G* the steam weight is $1.0497 \div 1.4349 = 0.7315$ pound, and the steam volume is $0.7315 \times 26.62 = 19.47$ cubic feet. At *E* the steam weight is $1.2676 \div 1.4349 = 0.8834$ pound, and the steam volume is $0.8834 \times 26.62 = 23.52$ cubic feet.

If various points upon the lines *B C*, *F G* and *D E* should be taken, at other temperatures than 212 degrees, the same computations could be performed, and the weight and volume of steam formed, by the time expansion had proceeded to the pressure corresponding to that temperature, could be known. Such investigations might be made at temperatures higher than 212 degrees, as along the 300-degree line, corresponding to a gage pressure of 52.5 pounds, for instance, or at lower temperatures than 212 degrees, as along the 125-degree line, corresponding to a vacuum of 26 inches.

If the steam volumes thus derived be laid off, with their corresponding pressures, on a rectangular diagram the re-

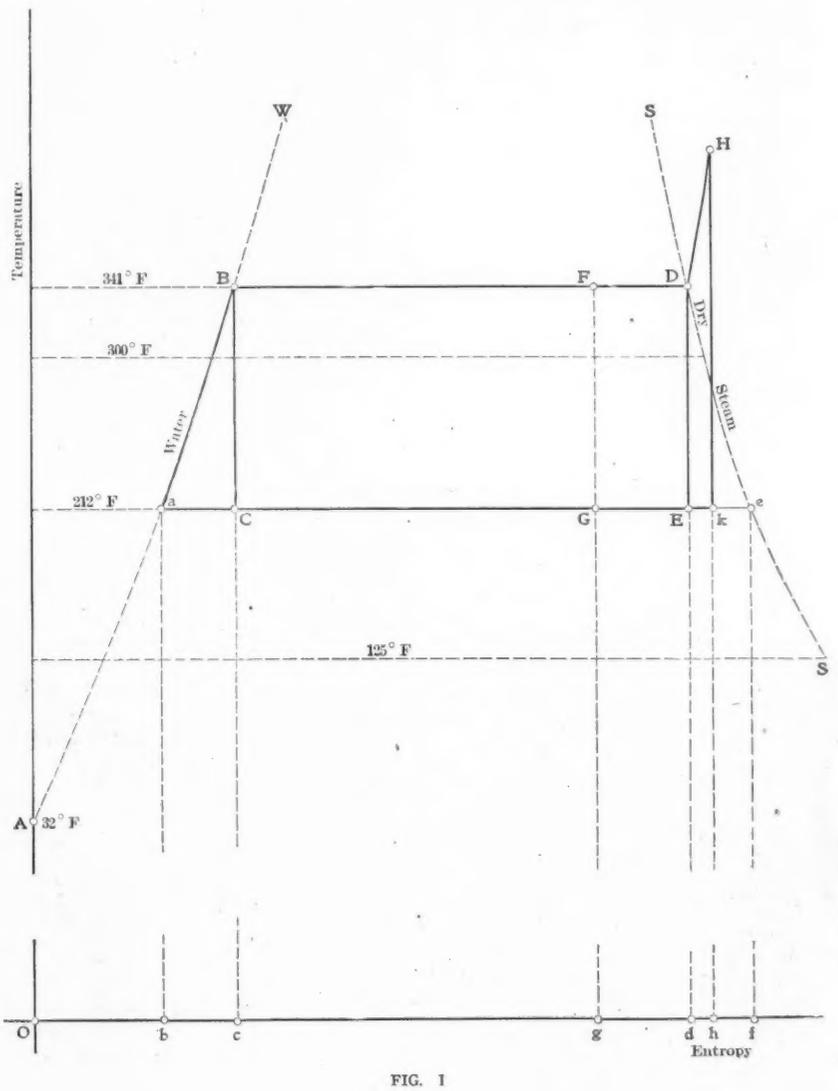


FIG. 1

sult will be like Fig. 2, which would be the indicator diagram of an ideally perfect steam engine, if we had one; that is, an engine whose walls conducted no heat, whose valves and piston were perfectly tight, and whose expansion was complete.

The reference letters of Figs 1 and 2 are in agreement. In Fig. 2 *a B C* would be the "indicator card" of a boiler explosion—and if anyone should ever succeed in taking one it would be found to be an almost perfect diagram, for there would be no time during the explosion for either leakage or heat loss. Similarly, *a B F G* would be the indicator diagram for an ideal engine working with wet steam, and *a B D E* the same when working with dry steam.

The line *S S* is the curve found by plotting the columns of pressure and volume of one pound of dry saturated steam which are found in the steam tables. *It is not a curve representing any process.*

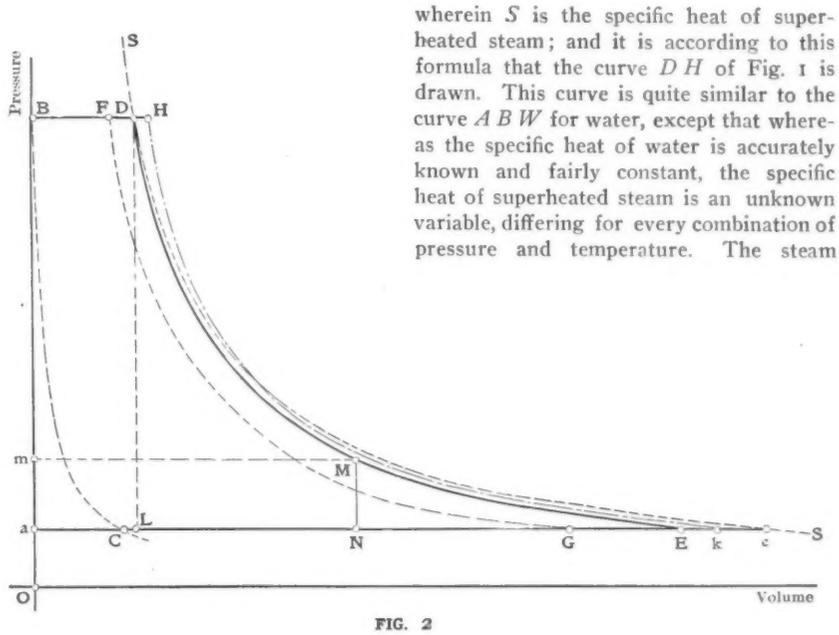


FIG. 2

Steam never follows the saturation curve.

It is to be noted carefully that the foregoing methods of computation, which involve nothing but the simple arithmetic of rectangular areas, are the *only known means* for deriving the true curves of Fig. 2. Various algebraic formulas will be found published, giving the relations between pressure and volume in steam expanding from a given initial condition. These formulas are not only cumbrous to handle, but *they are inaccurate.* The true relations between the pressure and volume of expanding steam cannot be expressed algebraically.

This need not trouble us, for the exact methods given herewith are also much simpler, and will solve almost all steam problems ever arising. It will be noticed immediately that Fig. 1 is a much clearer diagram on which to follow the different processes, most of which are shown by straight lines, than is Fig. 2, where the several hyperbolic curves are so nearly parallel as to be very confusing.

Superheated Steam

The use of superheated steam calls for the first appearance in the entropy diagram of anything approaching mathematical complexity. If the pound of dry saturated steam of 120 pounds pressure which has served in the illustrations be further heated after leaving the boiler, it will rise in temperature and increase in volume at constant pressure, as shown by the lines *D H* of Figs. 1 and 2. The law of increase of volume is not known exactly for superheated steam. For present purposes it will be assumed that the volume is proportional to the absolute temperature.

The increase of entropy, as the temperature rises, is given by the formula

$$N - N_D = 2.3026\, S \log \frac{T}{T_D},$$

wherein S is the specific heat of superheated steam; and it is according to this formula that the curve *D H* of Fig. 1 is drawn. This curve is quite similar to the curve *A B W* for water, except that whereas the specific heat of water is accurately known and fairly constant, the specific heat of superheated steam is an unknown variable, differing for every combination of pressure and temperature. The steam tables can give the entropies of water, but for superheated steam each entropy must be computed; and the authorities do not always agree as to the value of S to be used in doing so. We know approximately that it varies from some such value as 0.30 or 0.40 for pressures well below atmospheric to about 0.45 or 0.50 at atmospheric pressure, and to 0.60 or 0.70, or perhaps even 0.80, at high boiler pressures and superheats. Yet, however desirable better information upon this topic would be, the lack does not heavily affect present computations; for the entropies of superheat are all small in comparison with those to which they must be added.

For instance, suppose that the illustrative engine, supplied with boiler steam of 120 pounds pressure, used steam superheated to 420 degrees Fahrenheit. There may be assumed for these conditions a value for S of 0.60. The additional heat required, per pound of feed-water handled, is then $0.60 \times (420 - 341.1) = 47.3$ B.t.u. This is measured in Fig. 1 by the area *d D H h*. The additional entropy involved, *E k*, is $2.3026 \times 0.60 \times \log \frac{880.8}{801.9} = 2.3026 \times 0.60 \times (\log 880.8 - \log 801.9) = 0.0564$. Adding these values to those already found for the case of dry saturated steam, which expanded down the line *D E*, we find that the heat supplied is $1004.7 + 47.3 = 1052$ B.t.u. The heat still in the steam at *k* is the area beneath *a k*, or $673\ (1.2676 + 0.0564) = 891$ B.t.u. The heat converted into work is therefore $1052 - 890 = 161$ B.t.u. $= 125{,}258$ foot-pounds per pound of steam used. The efficiency of the cycle is $161 \div 1052 = 15.3$ per cent.

It will be seen from this that *theoretically* the use of superheated steam improves the efficiency as slightly as the use of wet steam deteriorates it. This shows that the chief value of superheated steam, which in reality very much improves the efficiency, is that it minimizes those wall losses which pull the actual efficiency, with saturated steam, far below the theoretic. These losses are chiefly due to the presence of moisture. The value of superheat, as of the steam-jacket, is that it contributes heat to the cylinder without at the same time contributing moisture.

Before the simple computation given above may be accepted, however, care must be taken to ascertain whether the point *k* lies inside of *S S* or not. In this case it does; for the value of *a e* had already been found to be 1.4349, and now *c k* proves to have the value 1.3240. Had the superheat been appreciably above 500 degrees, however, the point *k* would have fallen to the right of *e*. In that case a somewhat more complex solution would have been necessary. It need not be given here, for engines using superheat usually exhaust into a condenser, at the level of the 125-degree line or below it, and seldom use enough superheat to carry *k* to the right of the position which *e* then takes.

Non-expansive Working

Hitherto it has been assumed that the expansion is complete. But it seldom is. Non-expansive action can be understood best by taking its extreme case, which is where there is no expansion at all, as in the direct-acting steam pump. Imagine such a pump, using steam of 120 pounds pressure, to be of such a size that it takes in just one pound of steam per stroke. Of course, the action and efficiency of each pound of steam are the same, whether it all acts in one stroke or is divided between several. But it is easier to imagine it as working just one pound at a time.

The one-pound cylinderful of steam, or 3.71 cubic feet, would be shown by the point *D*, Figs. 2 and 3. Now the steam valve is shut and the exhaust opened, while the piston remains at rest at the

end of its stroke. There remains in the cylinder always just 3.71 cubic feet of steam; but as the pressure drops this volume represents less and less *weight* of steam. More and more of the original pound has gone out the exhaust. By the time atmospheric pressure has been reached, where one pound of dry steam occupies 26.62 cubic feet (according to the steam tables), the cylinder contains only $3.71 \div 26.62 = 0.1394$ pound of steam. Its entropy, $a\,L$, Fig. 3, is $0.1394 \times 1.4349 = 0.2004$.

In this case it is more convenient to compute the work done from the pressure-volume diagram, Fig. 2, for there it is shown as a simple rectangle; whereas in the entropy diagram there is no known equation for the constant-volume curve $D\,L$ (Fig. 3). From the rectangle $a\,B\,D\,L$ of Fig. 2 the work done is $(120 - 14.7) \times 144 \times 3.71 = 56{,}260$ foot-pounds $= 72.32$ B.t.u. (The factor 144 appears because the pressure must be stated in pounds per square foot, the volume being stated in cubic feet.) The efficiency is $72.32 \div 1004.7 = 7.2$ per cent., a result much lower than with complete expansion.

Most engines, however, work with *partial* expansion, as along such a cycle as $a\,B\,D\,M\,N\,a$ (Figs. 2 and 3). In that case the problem must be solved in two portions. The cycle must be divided into two, the expansive cycle $m\,B\,D\,M\,m$, and the non-expansive cycle $a\,m\,M\,N\,a$. Each can be treated according to the examples already given, and the results added.

Here arises an interesting question as to the most profitable back pressure for a direct-acting pump, considering only the efficiency of the pump itself. Suppose that the exhaust pressure of the pump just studied were dropped enough to bring down the exhaust temperature one degree. The cycle would then be extended by the little dotted horizontal area $a\,L$. But the same change would lower the feed-water temperature one degree, and add one heat unit to the heat required per pound of steam made. Have we gained or lost by the change?

The curves $B\,a$ and $D\,L$ are nearly enough parallel so that, for one degree of drop, the area $a\,L$ may be considered a parallelogram. Its area would then be $1 \times 0.2004 = 0.2004$ B.t.u. We have therefore gained work, for the extra heat unit invested, at the rate of 20.04 per cent., which is an improvement upon the previous efficiency of 7.2 per cent.

This improvement will continue (theoretically) until the entropy value equals the original efficiency, which in the present case would occur when specific entropy of vaporization $\times$ (3.71 $\div$ specific volume) equals 0.072, or specific volume $\div$ specific entropy of vaporization $= 3.71 \div 0.072 = 51.53$. The steam table tells us that this level is 156 degrees Fahrenheit, or 21 inches of vacuum. Actually, however, condensation would divide all these volumes by about two, placing the most profitable exhaust pressure at a specific volume = entropy ratio of 26.8, or 13 inches of vacuum. Below this point it will not pay to go. With a boiler pressure above about 160 pounds by gage, indeed, atmospheric pressure is below the most profitable point of exhaust. The efficiency of the pump will be improved by back pressure.*

One of the most valuable features of the entropy diagram is its ability to indicate clearly whether the steam is absorbing or being robbed of heat. One of the fundamental characteristics of entropy is this: When heat is added to a body its entropy increases; when heat is abstracted its entropy decreases; but when *work* is added or abstracted (with no addition or abstraction of heat) the entropy remains constant, as along the adiabatics $D\,E$ or $D\,R$ (Fig. 4.). In an entropy diagram, therefore, every departure of a curve to the right means the absorption of heat by the steam; and the area beneath the departure measures the amount absorbed. Every departure to the left means the giving out of heat, by radiation or conduction, similarly measured in quantity by the area beneath, down to the zero axis. Every vertical drop means the giving out of work, in expansion. Every vertical rise means the absorption of work, in compression.

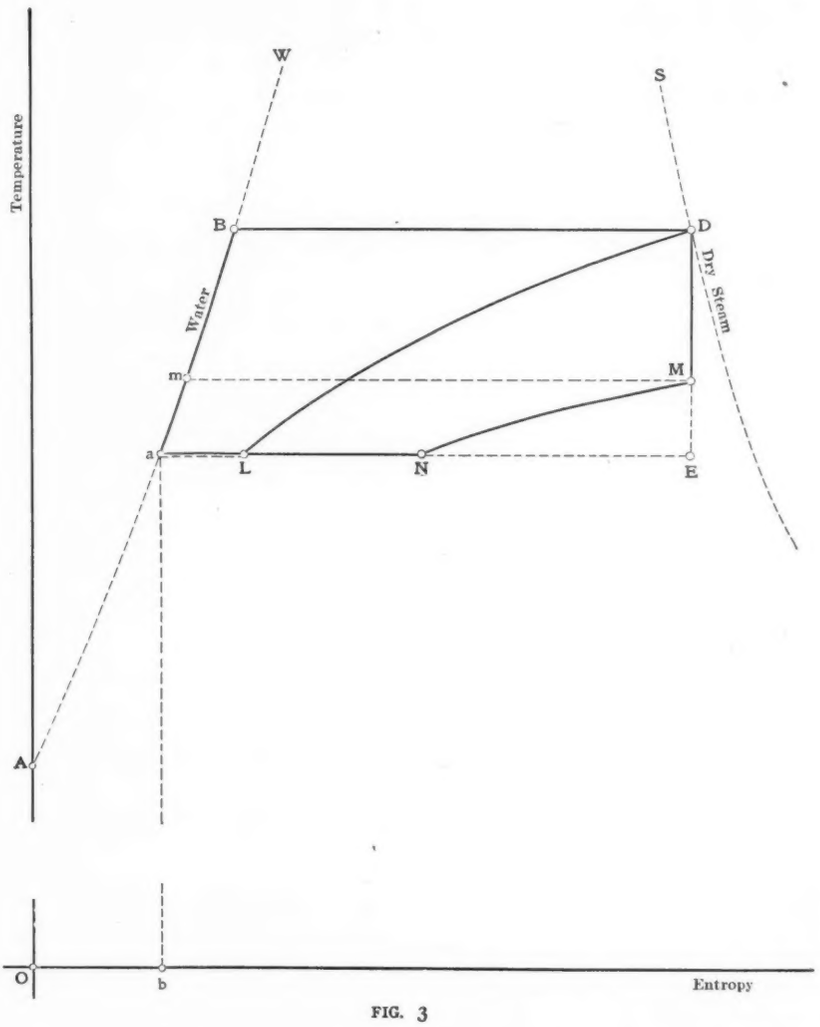


FIG. 3

Wire-drawing

Unquestionably, one of the most valuable features of the entropy diagram is its facility for tracing the action of *steam friction*, which is of so much importance in steam-turbine action. Suppose that the hot boiler water at B, Fig. 4, were blown off through a pipe so long that virtually all its energy were consumed in friction, but that the pipe were so well covered that *no other heat action took place*. As the hot water feels the pressure upon it lessening, as it enters the blow-off, it insists upon doing work, just as it did in the boiler explosion. But now there are no flying bricks and boiler-plate to absorb the work; there are only the particles of water and steam, which are sent flying through the blow-off. But this work, instead of staying work, is immediately re-

*The slide-rule gives a convenient means of finding these steam-table values from the computed ratio between specific volume and entropy. The rule should be set at the given ratio. The slider may then be readily adjusted to the point where the hair-line reads a specific entropy on the upper scale and a specific volume on the lower scale, which are found on the same line of the steam table.

converted into heat by friction. And there is nothing to absorb this heat except the water. That is to say, the heat in the water, finding itself free, or partially so, to perform work, tries to drop down the plumb-line adiabatic *B C*. But as it goes its own heat (to the amount which it had just got rid of, in the form of work) is thrust back upon it, and must be re-absorbed. Its path is thus distorted to the right, from *B C* to *B Q*.

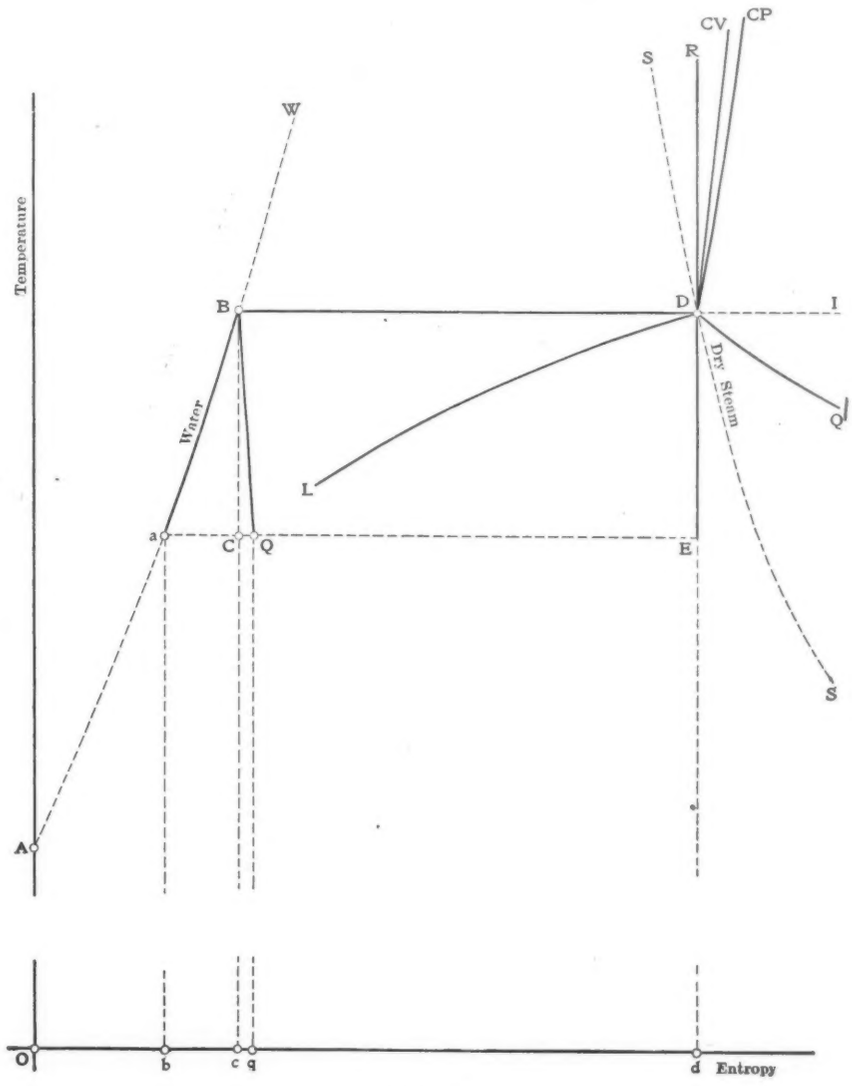


FIG. 4

To explain this plumb-line, or adiabatic, drop of heat, the writer often uses the simile of a farmer, who goes into town with a wagon-load of produce for sale. No one robs him; yet at night he returns with his wagon empty. Presumably he has exchanged his produce for cash. The heat in adiabatic (or "uninterfered with") expansion is like the farmer's sale. No one robs him of his produce, just as nothing robs the steam of its heat, if the process be an honest, adiabatic one. Yet at the end of the stroke the steam's heat is largely gone. The steam has been relieved of *work*, which the steam molecule exchanges for *in exchange* would be gone, spoiled upon his hands by time and too much handling.

But suppose that, as fast as the farmer made his sales, produce previously sold was brought back to him as undesirable, forced upon his hands again, and money demanded in full. At the end of the day he would still possess his full stock of goods, but its *availability as wealth* heat within its own pockets, just as the farmer willingly loses the produce which he worked so hard to raise, *if* he be allowed to exchange it for cash.

Quite the same would be the case of the heat in the blow-off water and steam. Their particles are able to take up a small portion of the work which the temperature drop forces the heat to get rid of but they cannot keep even that. They can take it up only in the form of motion, rapid motion; and motion immediately begets *friction*. But friction is only a name for the conversion of work back into heat. So, at the end of the process the steam possesses its full original stock of heat, but it is now low-temperature heat instead of high-temperature heat. Its usefulness is gone. Wire-drawing is always a loss of usefulness.

Such wire-drawing processes are shown by the curves *B Q* and *D Q'*, Fig. 4; *B Q* being characteristic of any process wherein *hot water* is reduced in pressure by flow against frictional resistance, and *D Q'* typical of similar processes with *dry steam* of any given original pressure. Similar curves might be drawn, of course, starting from any point on *B D*, representing the wire-drawing of wet steam. The characteristic of all these curves is that the heat present at any point, measured by the area beneath *O A B D* or similar constant-pressure lines, is a constant. They are therefore called *constant-heat* curves.

What are the steam weight and volume at *Q*? The area *O A B c* must equal the area *O A a Q*, for the heats at beginning and end are equal. Therefore, *b a B c* = *b a Q q*. But *b a B c* has already been found to be 131 B.t.u. Therefore *b a Q q* = 131 B.t.u. Now the latent heat for the complete vaporization of one pound at the *a e* level is 965.4 B.t.u. Therefore at *Q* there must be on hand $131 \div 965.4 = 0.1359$ pound of steam. Its volume is $0.1359 \times 26.62 = 3.618$ cubic feet. At *C* the steam weight was 0.124 and the volume 3.30 cubic feet.

Had the blow-off been attached above the boiler's water level, so that dry steam was blown off, the process would have been shown by the curve *D Q'*, more nearly horizontal than *B Q*, but involving the same principles.

These *constant-heat* curves are of value in showing the action of the throttling calorimeter, but it is in steam-turbine work that they become all-important. The true action of working steam, whether in a piston engine or a turbine, is the adiabatic *D E*. In the piston engine the action of the walls always *detracts* heat and entropy, forcing the actual path to the *left* of *D E*. In the turbine there is no wall action abstracting heat, because at each point temperatures remain constant; but there is always wall action (friction) abstracting *work*, and returning it as heat. And this always *adds* entropy, forcing the actual path to the *right* of *D E*. In the piston engine the actual path always lies somewhere between *D E*, representing perfect action, and *D B*, representing no work done at all. In the turbine the actual path always lies between *D E*, for perfect action, and *D Q'*, for totally bad action, all usefulness being wasted in steam friction.

General Steam Action

We are now equipped for using the entropy diagram for its most valuable purpose of all, viz: *the carrying with one of a clear idea of what will be the result of any sort of action in or upon steam.*

The point *D*, Fig. 4, represents dry saturated steam of any given pressure. There are only seven different things

which may be done to this steam, in engine-room happenings, each of which is one simple process, as follows: The steam may be:

1. Condensed at *constant pressure,* along *D B,* by abstraction of its heat. The diagram shows that, if the pressure be kept constant, there can be no drop in *temperature,* from "cooling," until after the steam is all water; only the volume decreases.

2. Condensed and cooled at *constant volume,* along *D L,* by simple heat-abstraction. Both pressure and temperature fall as the heat goes.

3. Cooled and condensed by *adiabatic expansion,* along *D E,* by the abstraction of *work* only. No heat is abstracted; yet the heat fund decreases, moisture is formed, and both temperature and pressure fall. The volume increases.

4. Cooled and superheated by *wire-drawing,* along *D Q'.* The temperature falls, yet the steam is dried if wet, and superheated if already dry. The volume increases.

5. Heated at *constant pressure,* along *D C P.* Temperature rises, volume increases, but pressure remains constant.

6. Heated at *constant volume,* along *D C V.* Temperature and pressure rise.

7. Heated and superheated by *adiabatic compression,* along *D R.* Pressure and temperature rise; volume decreases; no heat is added, but work is added and the heat fund increases.

To succeed in remembering all of these combinations clearly, from their mere statement in words, is beyond ordinary minds. But with the entropy diagram and its few basic rules well in mind, the effect of not only any process, but any combination of processes, no matter how complex, can be quickly and accurately defined.

The final task is to recall clearly to mind the things which do *not* happen in steam. These are shown in Fig. 4 by broken lines.

First, there is no possibility of altering dry saturated steam of one pressure or temperature into dry saturated steam of any other pressure or temperature by any single process; or, for that matter, by any practicable combination of processes. The curve *S S* does not represent a process. It would take an impracticable, delicately balanced combination of compressing and cooling, or of expansion and heating, to force steam to follow *S S.* In practice it never occurs.

We sometimes hear the term "specific heat of saturated steam." There is no such thing. No amount of supply or abstraction of heat will ever alter saturated steam by one degree Fahrenheit—which is what the words "specific heat" mean—and still leave it saturated steam.

Second, any isothermal, such as *D I,* in the field of superheated steam, or of any other superheated gas, is a monstrosity. Isothermal processes with superheated steam *never occur.* The only natural occurrence of isothermals is in a *change of physical state,* as in the vaporization of water or the melting of ice; and *there the isothermal is always a constant-pressure process.* The so-called isothermal equation for air, $PV = a\ constant$, is a very useful crudity where crude approximations are useful, as they often are in the drafting room; but it has almost no proper part in the understanding of the thermodynamic action of steam. In studying either the principles of thermodynamics or the action of the steam engine this equation belongs in the same classification with the "perfect gas," the solid molecule and the absolute zero of temperature—as picturesque but legendary monsters of the past, which men have spent much time in imagining and depicting, but which never have existed and never need to exist, even to help men to the highest understanding of and the highest faith in nature.

Wiring for Motors

By N. A. Carle

In selecting the size of wiring for motor circuits it is necessary to consider the horse-power or kilowatts capacity of the motor and its efficiency, the excess carrying capacity of wires demanded by the Fire Underwriters to provide for overloading of motors, the voltage and length of the circuit and the allowable voltage loss.

Motors are usually operated on 110-, 220- and 500-volt circuits, with efficiencies from 65 to 95 per cent. at rated capacity.

The excess carrying capacity required by the Fire Underwriters is usually 25 per cent. beyond the ampere input of the motor at rated capacity. The required ampere capacity having been determined, the size of wire is expressed by the formula:

$$c.m. = \frac{10.7 \times I \times L}{E},$$

where

$c.m.$ = Area of cross-section of wire in circular mils,
I = Current in amperes,
L = Whole length of circuit,
10.7 = Average ohms resistance of one mil-foot of copper wire.

The chart on page 839 is designed to read directly the size of wire to be used in accordance with the Fire Underwriters' requirements, either for open or concealed work, for motors up to 80 horse-power or 60 kilowatts capacity, with efficiencies from 65 to 95 per cent, and for 110-, 220- and 500-volt circuits of lengths from 100 to 1400 feet, and for drop in volts up to 15.

Example

What size of wire should be used for open work for a 50-horse-power 220-volt motor having an efficiency of 85 per cent. at rated capacity, to give a drop not to exceed 8 volts on a circuit of 500 feet total length?

Starting with 50 "Horse-power" read up to "220 Volts," then across to 85 per cent. "Efficiency of Motor," and drop a vertical line from this point across the lines representing the "Size of Wire." Then starting with 8 "Volts Lost" read up to 500 feet "Whole Length of Circuit," then across to the intersection of this line with the vertical line mentioned above, which will give the proper "Size of Wire" as No. 000. This intersection comes within the Fire Underwriters' limit line for "Open Work."

Example

What is the smallest size of wire that can be used in open work for a 75-horse-power 500-volt motor having an efficiency of 90 per cent. at rated capacity?

If the length of circuit is 700 feet, what will be the drop in voltage?

What is the smallest size of wire that can be used for conduit work and what will be the drop under the above conditions?

Starting with 75 "Horse-power" read up to "500 Volts," then across to 90 per cent. "Efficiency of Motor" and down to the smallest size of wire within the Fire Underwriters' limit line for "Open Work." This gives a No. 1 wire. Then read across to 700 feet "Whole Length of Circuit" and down to 14 "Volts Lost."

For conduit work start as before with 75 "Horse-power" and read up to "500 Volts," across to 90 per cent. "Efficiency of Motor" and down across the "Size of Wire," but stopping before the Fire Underwriters' limit line for "Concealed Work" is reached. This gives a No. 000 wire. Then read across to 700 feet "Whole Length of Circuit" and down to 6.9 "Volts Lost."

Free Engineering Library Open Evenings

The reference libraries of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Institute of Mining Engineers, 29 West 39th street, New York, will be open evenings until nine o'clock on all week days except public holidays. These libraries, constituting practically one library of engineering, situated near the New York Library, in the new headquarters of the Engineering Societies, are available to members of the three societies and to engineers and the public generally, subject to proper regulations. Strangers are requested to bring letters of introduction from members or to secure cards from the secretaries of the respective societies.

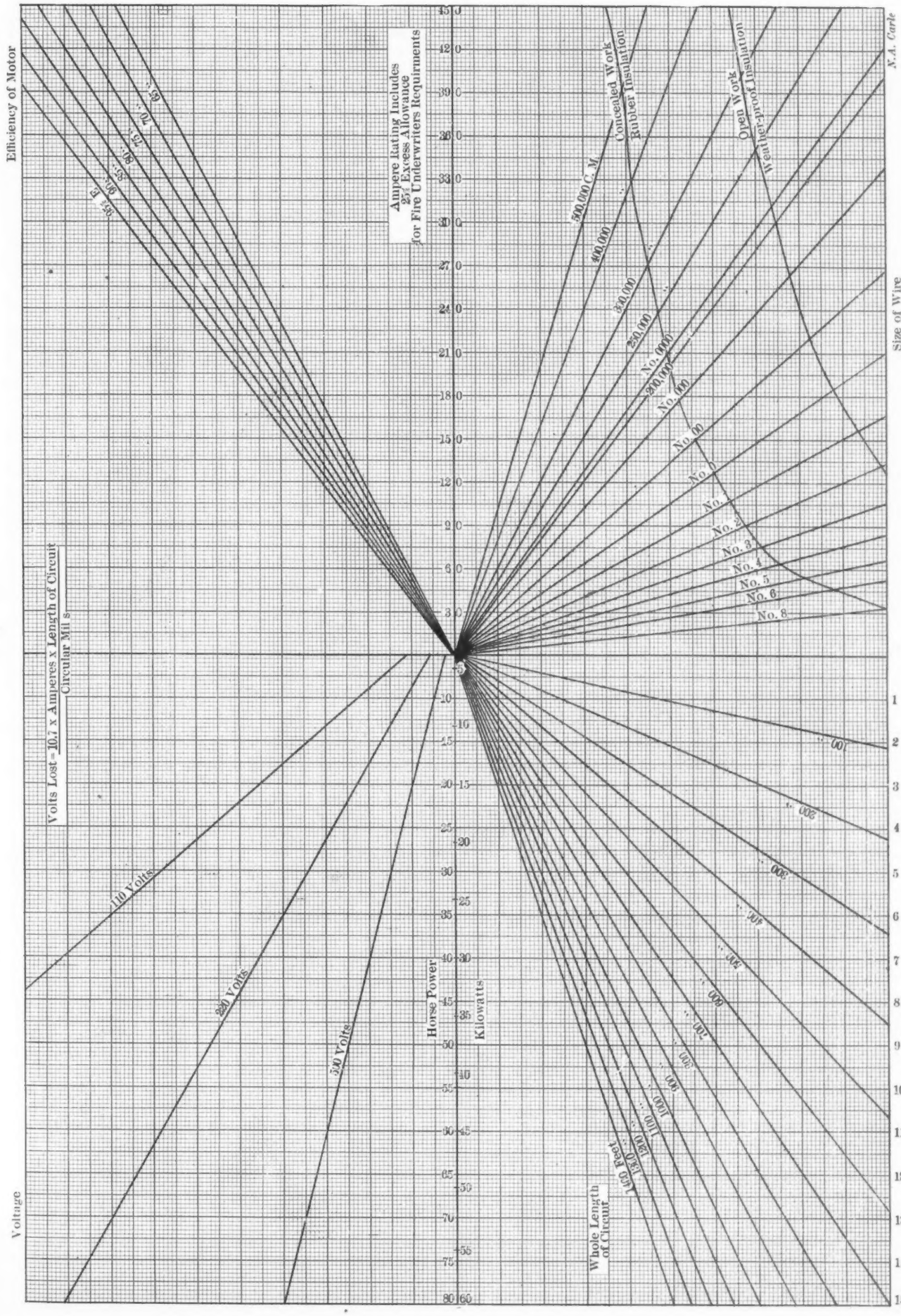


DIAGRAM FOR DETERMINING SIZES OF WIRES FOR MOTORS

Technical Aspects of Oil as Fuel—III

Use of Coal-tar Oils in Engines of the Diesel and Similar Types; Benzol Supplanting Gasolene; Characteristics and Use of Tar Oils

BY FRANZ ERICH JUNGE

Although there has been a constant increase in the application of oil engines, especially those of the Diesel type, all over Europe, their more general adoption and use on a large scale (in Germany*) has been largely hampered through the fact that the oils which could hitherto be used in these engines with success were entirely too high-priced, so that the unchallenged efficiency of utilization was more than outweighed by the excessive first cost of the fuel. It became of the utmost importance, therefore, for the direct interests to get hold of a cheap and readily available fuel, such, for instance, as the various coal-tar oils, and to determine by theoretical analysis and practical experimentation their technical possibilities and limitations as competitors of the ordinary crude oils and petroleums, which are used in European industrial pursuits, and of which by far the greatest quantity is imported from abroad. The principal questions embraced by the investigation were: Which coal-tar oils are applicable and which are not applicable in direct engines, and where is the limit when the two are mixed? What considerations determine their applicability or their unfitness as fuels for power generation?

To answer these questions authoritatively experiments were made in the laboratories and testing plants of the Vereinigte Maschinenfabrik, Augsburg, and Maschinenbaugesellschaft, Nürnberg (builders of the Diesel engine), and in the mechanical laboratory of the Technische Hochschule, Charlottenburg. Further, in the chemical laboratories of the Industrial Museum at Nürnberg and of the Institut für Gärungsgewerbe, in Berlin. The results of these experiments were recently presented by Paul Riepel, Nürnberg, in the *Verein deutscher Ingenieure;* and a condensed survey of the essential parts of this report is reproduced herewith.

*The Haselwander, the Trinkler and the Brons motors, as built in Germany, are similar in action to the Diesel engine and can burn heavy oils without difficulty, though, perhaps, not with the same thermal efficiency and fuel economy as the Diesel engine.

Operative-technical Investigation of Coal-tar Oils

With the exception of small quantities there are two principally different kinds of oil obtained from wood and peat tar, of tar oils available, those made from brown-coal tar and those made from hard-coal tar. Until a short while ago it was thought that while the first-named species could be used as fuels in oil engines, the last named were not applicable at all.

(a) Experiments with brown-coal tar oils: These oils are a distillation product of brown coal, which is of the lignitic caking variety, mined in large quantities in Germany and Bohemia, and in still greater quantities in North Dakota and Texas in the United States. For use in Diesel engines only the cheaper grades of these oils, those of low paraffin content, having specific gravities between 0.860 and 0.926, are applicable, and such have given good results for some time. It was found, however, that operative difficulties would occur as soon as their paraffin content increased beyond 2.5 per cent.; at least, this had been the experience of owners of Diesel engines. On the other hand, oils with from 2 to 15.2 per cent. of paraffin content did not give any trouble whatsoever when the engines were operating on the testing floor, for 52 hours and more; so it was concluded that the paraffin content alone was not responsible for any of the operative difficulties, but that together with the paraffin other harmful constituents were introduced, which interfered with the successful working of the machine. Crude oils and foreign gas oils, with a considerably higher paraffin content than 2.5 per cent., had never given any trouble. Further, the influence of the viscosity of the oils on the thermal efficiency of the combustion process was examined. Five different mixtures of paraffin oil, with soft solid paraffin of different vicosity but with the same physical and chemical properties, were tried. It was found that, other conditions being equal, a certain viscosity value would give maximum thermal efficiency, but owing to the small difference in viscosity of the oils used in practice this feature is hardly of importance for the operation of the engine.

(b) Experiments with hard-coal tar oils and mixtures: Similar to what ob-

TABLE SHOWING CHARACTERISTICS OF SOME FUEL OILS.

	No.	Name of Oil.	Spec. Grav. at 15 Deg. Cent.	Lower Heat Value, Calories per Kg.	Viscosity at 80 Deg. Cent.	Flash Point, Deg. Cent.	Burning Point, Deg. Cent.	Elementary Analysis. H %	C %	H : C
Useful Oils for Diesel Engines.	1	Raw oils from brown-coal tar—I	0.908	9.799	1.02	....	....	12.42	85.64	1.74
	2	Raw oils from brown-coal tar—II	0.878	9.520	1.03	....	....	11.27	84.38	1.60
	3	Gas oils from brown-coal tar	0.893	9.799	1.09	....	....	11.62	85.71	1.56
	4	Paraffin oil—I	0.916	9.732	1.01	98	112	11.53	85.95	1.54
	5	Paraffin oil—II	0.926	9.749	1.04	96	111	11.63	85.98	1.55
	6	Soft paraffin	0.894	9.901	1.13	123	142	11.81	85.73	1.58
	7	Gas oil from petroleum—I	0.855	9.756	1.12	74	107	13.60	83.71	1.95
	8	Gas oil from petroleum—II	0.900	9.916	1.34	82	129	11.24	86.80	1.56
	9	Liquid fuel	.....	.....	....	137	152	11.37	85.10	1.60
	10	Rumanian crude oil	0.858	9.982	1.08	<10	<10	12.31	83.10	1.78
	11	Rumanian gas oil	0.853	9.896	1.03	66	101	12.22	85.03	1.73
	12	Solar oil	0.849	10.105	1.01	81	106	13.30	85.67	1.86
	13	Tegernsee crude oil	0.868	9.940	0.98	56	81	11.09	86.95	1.53
	14	Texas gas oil	0.892	9.890	....	114	128	12.20	86.40	1.70
	15	Refined petroleum	0.879	10.610	1.03	57	72	14.20	85.10	2.00
Undesirable Oils for Diesel Engines.	16	Anthrazen oil	1.091	8.959	1.12	111	127	6.89	89.10	0.92
	17	Creosote oil	1.050	8.965	0.96	86	101	6.13	91.20	0.81
	18	Webau mineral oil	0.977	.....	1.05	79	91	9.60	91.00	1.26
	19	Ergin	0.887	9.685	0.84	31	37	9.15	89.78	1.22
	20	Raw benzol	.....	9.965	0.82	<10	<10	7.59	90.80	1.00
	21	Tar oil, Blaugasfabrik	0.909	9.721	0.87	....	....	7.18	91.07	0.95
	22	Tar oil, Pasing	0.984	9.078	0.93	72	87	8.19	90.30	1.08
	23	Tar oil, Lothringen mine	0.957	8.992	0.85	51	60	7.46	91.15	0.98
	24	Tar oil, Erkner, A	.....	.....	....	....	....	7.50	89.56	1.01
	25	Tar oil, Erkner, B	.....	.....	....	....	....	7.75	90.60	1.03
	26	Crude oil, Löwenbach	0.922	.....	1.52	25	44	....	.....	....

tains with brown-coal tar oils, only the cheaper fractions of hard-coal tar, namely, those which distil over at the higher temperatures and contain only limited quantities of benzol and toluol, are commercially applicable. As the name implies, these oils are obtained from coal tar, and this in turn is obtained as a by-product of the destructive distillation of hard coal, in coke-oven and city gas works. The distillation of tar is usually divided into five fractions. For use in Diesel engines only the last two distillates, namely, creosote oil and anthrazen oil, which boil at a temperature of about 240 degrees Centigrade, would come under consideration. These oils can be sold at a very low price, ranging from 25 to 50 marks per 1000 kilograms ($6 to $12 per ton), while the price of brown-coal tar oils ranges between 80 and 110 marks per 1000 kilograms ($19 to $26 per ton). Since the growing annual production of (hard) coal-tar oils in Germany has reached, within the last year, more than double the output of paraffin oils, the exact ratio being 84,000 tons to 40,000 tons, and since a similar increase is expected in the future, the possibility of employing these oils as fuels for power generation offers a promising road toward self-controlled stability of the sources of liquid-fuel supply for industrial operations within the borders of this country.

Majority of Tests Made on a Diesel Engine

The majority of fuel tests were made with a 35-horse-power Diesel engine on the testing floor of the Augsburg works. Twenty-one different mixtures of coal-tar oils with paraffin oil and coal-tar oils with solar oil (from petroleum and gas oil) were examined in a series of 38 tests. Creosote oil and anthrazen oil are by-products obtained from the petroleum refinery in Germany. They are extracted in small quantities, cost about the same as paraffin oil and have been used in Diesel engines with good success. As one result of these trials it was proved that benzol (C_6H_6) is not applicable in these engines, since it is even more difficult to handle than the heavy coal-tar oils, such as anthrazen oil and creosote oil. When running on the last-named fuels vehement explosions in the engine were recorded, and pressures were indicated up to 55 atmospheres. On the other hand, ignition failed entirely sometimes, the exhaust leaving the pipes as a thick cloud of soot and sparks, so that after a short while the valves and piston of the engine were covered with dirt. It was found impossible to run at anything below the normal load, since ignition would no longer take place. Mixtures of these oils with the better grades were only applicable within a small range if the operation was to proceed at varying loads without knocking and without the formation of soot. An admixture of 25 per cent. of hard-coal tar oil proved to be the extreme limit. If it is desired to run the engine only at normal and maximum loads, and if it does not matter that the internal moving parts get clogged after a while, then an addition of 40 per cent. is permissible. There was no appreciable difference in behavior as regards the kind of (better grade) fuel with which the hard-coal tar oil was mixed..

The operative-technical results of these numerous trials can be summarized briefly as follows: Coal-tar oils made from brown coal are applicable—with the exception quoted—as fuel for Diesel engines. The paraffin content of these oils itself has no influence on their applicability, but it may serve as a measure of their fitness since, together with the paraffin, other harmful constituents are introduced. The viscosity of an oil has very little practical bearing on the thermal efficiency of its utilization in the engine. Coal-tar oils from hard coal are not applicable as fuel in Diesel engines as ordinarily constructed. But if a lesser reliability of operation is allowed, they may be mixed with any better grade of oil in quantities of from 25 to 40 per cent., but this practice is by no means recommended.

Examination of the Reasons for the Different Behavior of Tar Oils

These investigations were made with a view to determine which qualities of the various oils are favorable and which unfavorable to their combustion efficiency. For this purpose it seemed desirable not only to compare the respective tar oils with each other, but also to embrace in the analyses other good and bad oils in order to arrive at correct conclusions. Only their physical and chemical properties could be examined, on account of the limited quantities available. At first the specific weights, the heat and viscosity values, the inflammation and burning points, and the elementary composition of the oils were determined. The values obtained are compiled in the accompanying table. It will be seen that those oils which are unfit for combustion in Diesel engines have a little higher specific weight and a lower heat value than those which are applicable as fuels. This feature cannot, however, be taken as a measure for judging their general usefulness. The viscosity values are entirely independent of the fitness of an oil for combustion purposes. Also, the inflammation and burning points, which are of importance for the combustion of oils at ordinary temperatures and pressures, have no bearing whatsoever on their combustion in Diesel engines. On the other hand, it is evident that the hydrogen content affords an important means for judging the range of applicability of an oil as fuel for such purposes as the above.

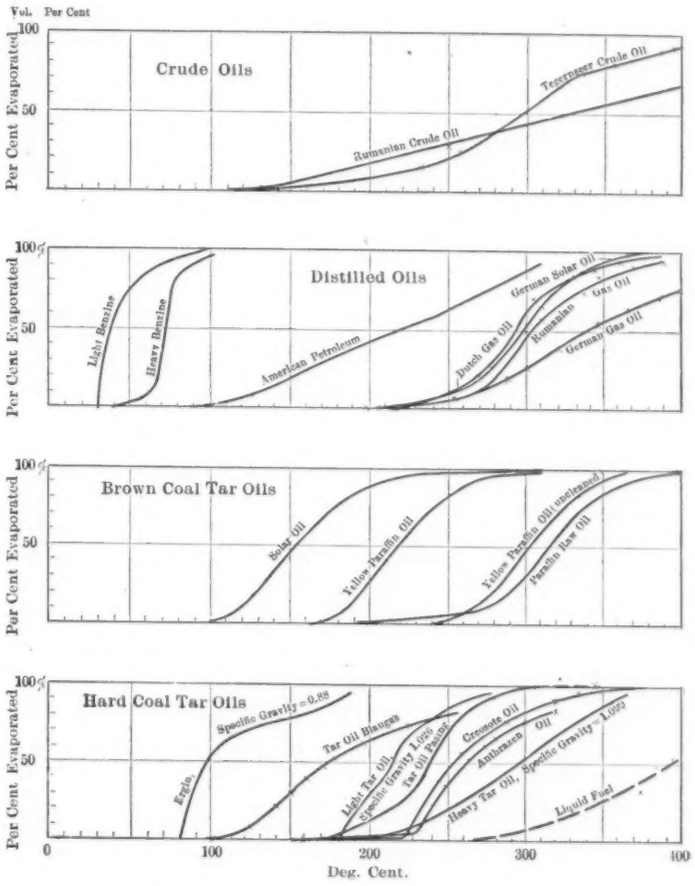


FIG. 28. EVAPORATION CURVES OF SOME FUEL OILS

The difference between the useful and

undesirable oils becomes even clearer when considering the ratio of the atomic weights of hydrogen to carbon, which is given in the last column of the table. The lowest value of this ratio figure is 1.53 for the good oils, as compared to a maximum value of 1.26 for the bad ones, and it should be remembered that the two better grades of oil, *18* and *19*, though not designated as "good," give far better results than the rest of the enumerated fuels. Together with what has been explained in the preceding, namely, that an admixture of 25 per cent. of anthrazen oil to paraffin oil does not appreciably disturb the quiet working of the engine, it can be stated that a ratio of the atomic weights of 1 to 1.39 (which is a mixture of 75 per cent. paraffin oil and 25 per cent. anthrazen oil) represents the limit between useful and undesirable oils. Thus it is seen that the elementary analysis of an oil offers an estimate or measure for its applicability in Diesel oil engines and similar types.

Analysis by Boiling

The evaporation curves of this analysis (which shows how many parts, in percentage, of an oil have been transformed into vapor at a certain temperature) are combined in Fig. 28, the different oils being presented on separate diagrams. The oils designated as "crude oils," "distillation products from crude oils," and "brown-coal tar oils," are all more or less suited for use in (Diesel) oil engines. The curves reveal a certain superiority of the brown-coal tar oils in regard to completeness and uniformity of evaporation. At the temperatures at which the oils are forced into the engine cylinder they are still in the liquid state, and they evaporate easily and uniformly below 400 degrees Centigrade without leaving any residues. Next in rank as engine fuels come the Rumanian and Dutch gas oils and the German solar oil. But German gas oil, as well as the ordinary crude oil, leaves considerable residue at temperatures of 400 degrees Centigrade, which appears like a tough, pitch-like, black mass, at ordinary (room) temperature. In Diesel engines temperatures of 500 and 600 degrees Centigrade prevail, owing to the high compression pressure employed, and it is estimated that during certain phases of the combustion process the temperature rises even beyond 1800 degrees Centigrade, probably up to 2000 degrees, so that all residues are consumed within the cylinder without difficulty.

When studying the evaporation curves of the hard-coal tar oils it will be noted that they show an irregular and fluctuating course, which means that evaporation does not proceed at a constant rate but that at certain temperatures some constituents evaporate suddenly, or in an explosive fashion, whereupon evaporation ceases entirely for a while. The behavior of the grade known as "liquid fuel" is especially noteworthy. This is a tar oil, obtained in Scotland from Canne coal and Boghead slate, which lends itself very well for use in Disel engines, in contradistinction to all other coal-tar oils from hard coals. This applicability is the more remarkable since the evaporation curve shows that at 400 degrees Centigrade only 53 per cent. of the oil has been transformed into vapor, while the rest remains as a pitch-like residue. During the period within which observations were made "liquid fuel" showed a quiet and comparatively uniform behavior similar to the brown-coal tar oils and distinctly different from those of the hard class.

Summarizing, it can be said that the evaporation of good fuel oils, such as show in their composition a greater uniformity, proceeds generally in quiet and regular order, while inferior oils as well as mixtures of different composition evaporate irregularly. Of, course, benzol (C_6H_6) is an exception.

The Behavior of Oils at High Temperatures and Pressures

In order to come as near as possible to the actual conditions under which combustion takes place in the Diesel engine Herr Riepel in his analysis has examined the evaporation pressures and the rate of gasification of different oils at various temperatures and pressures. The resulting heating and cooling curves are shown in Fig. 29. From this lengthy investiga-

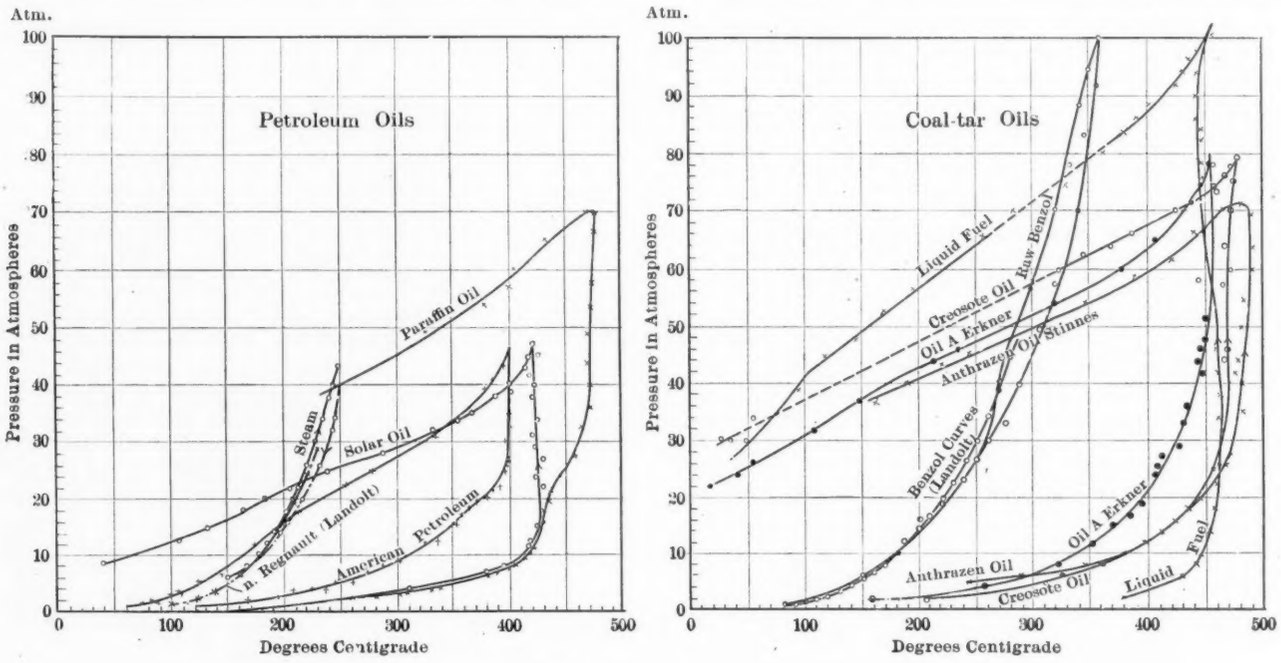


FIG. 29. CURVES SHOWING THE FORMATION OF OIL GAS FROM PETROLEUM OILS AND FROM COAL-TAR OILS

tion the following important facts are condensed: With rising temperatures the pressure of a mixture of different hydrocarbons increases at a fairly regular rate up to a certain point, whence the curve proceeds more or less vertically. In other words, when the heat influx is continued beyond that limit there is no further increase in temperature, but in pressure only, the additional heat introduced being expended for the decomposition of the oil mixture.

Further, the formation of oil gas exercises a determinating influence on the applicability of an oil in Diesel engines. Brown-coal tar oils, solar oil and petroleum are well fitted as motor fuels because gasification begins after comparatively little heat has been added, and hydrogen is liberated which ignites at 500 degrees Centigrade and provokes ignition of the rest of the fuel molecules.

For oils obtained from hard-coal tar the temperatures in Diesel oil engines are not sufficient, and do not prevail long enough, to provoke gasification. What takes place is more of an evaporation accompanied by incomplete combustion. The behavior of liquid fuel is again noteworthy in that it shows a curve entirely different from the rest of the hard-coal tar oils, which in turn do not differ materially from that of the brown-coal series.

General Chemical Composition of Oils

Almost all brown-coal tar oils represent a mixture of numerous members of the series shown by C_nH_{2n}, C_nH_{2n+2} and C_nH_{2n-2}. The hard-coal tar oils, on the other hand, belong mostly to the aromatic hydrocarbons, containing usually less hydrogen. Herein an explanation for the different behavior of the two classes is found; also in the fact that it is easier for the oxygen of the air to get access to the members of a long extended chain and to split them up into atoms or groups of atoms, than it is for it to reach the inner carbon kernel of a closed ring, such as is characteristic of the aromatic series (anthrazen, naphthaline, toluol, benzol, etc.) It is likely that combustion of the latter fuels proceeds more in an explosive fashion, after the outer layers have been destroyed by the influx of heat.

It is known that more heat is required to ignite fuels like coal, coke, wood and tar the higher the temperature at which they were formed or distilled. It is interesting to observe that hard-coal tar oils become more suitable as fuel in Diesel engines the lower the temperature at which they were distilled, and when they are thus suitable they become inferior in regard to the recovery of benzol, toluol, etc. This can be substantiated by comparing the degrees of applicability of the various oils for the formation of oil gas. A measure of their fitness for such purpose is afforded by the following:

Anthrazen oil, raw	...
Creosote oil	2.5
Benzol	...
Foreign distillates from crude oil	39.3
Paraffin oil—1	39.3
Paraffin oil—2	50.0
American petroleum	72.0

It is seen that the oils obtained from hard-coal tar give little or no oil gas and this is precisely the reason why they are not suitable for fuel in Diesel engines as now constructed. They can, however, be used in other oil engines, especially in those types which work with explosive combustion. They have also been used in Diesel engines, at a fuel cost of one-fifth of a cent per brake horse-power-hour, when the latter are equipped with certain modifications which are not yet ripe for publication. Summarizing the above investigations we arrive at the following résumé regarding the applicability of coal-tar oils in Diesel and similar engines:

(1) Oils gained from brown-coal tar (paraffin oils) can be used successfully as fuel in Diesel engines. Oils gained from hard-coal tar (anthrazen oil, creosote oil, benzol, etc.) are not applicable unless the working process of the engine is modified from slow to sudden combustion.

(2) For judging the applicability of oils to the above purpose the specific weight, viscosity, flash point, burning point and heat value are immaterial.

(3) Of greatest importance is the hydrogen content of the elmentary analysis, which allows one to venture on a conclusion regarding the presence, in the fuel, of a certain quantity of aromatic hydrocarbons.

(4) Self-ignition and combustion proceed the more certainly the better an oil is suited to form oil gas; that is, the larger the quantity of oil gas generated from the fuel at low temperatures and pressures. Oils obtained from hard-coal tar require for that purpose more and longer heat influx than paraffin oils.

(5) It is likely that in all liquid-fuel motors there are only two principal modes of operation to be distinguished: (a) The constant-pressure process (Diesel, Haselwander, etc.), characterized by the injection of liquid oil under pressure during the dead-center position of the piston, and provocation of ignition by the immediate formation of oil gas, without a special igniter. (b) The constant-volume or explosion process (Otto, etc.), characterized by the feature that no oil gas is formed, but that a mixture of oil vapor and air in correct proportions is ignited by external means, such as an electric spark, hot tube or similar appliance.

Gas Oils as Fuel for Internal-combustion Engines

Reference has already been made to gas oil, a material which is largely used in illuminating-gas works for carbureting water gas, also as a fuel in those types of oil engines which can burn successfully heavy oils without becoming clogged up, such as the Diesel, Haselwander, Trinkler, Brons, etc. Gas oil is gained in large quantities as a by-product of the oil refinery, from the residues which remain available after the light and the illuminating oils have been recovered from the raw product. It is also obtained, through fractional distillation, from brown-coal tar, though in lesser quantities, being used both for carbureting and for motive-power purposes, after the costly paraffin has been removed from the oil.

The latter mode of production has originated in those European countries which possess few or no oil wells of their own, while the import of foreign raw and refined oils is hampered by high tariff rates. In Germany these import duties form a considerable source of income to the government. They also serve to stimulate or encourage the coal-tar industries to invent and perfect new apparatus and processes which will enable them to utilize in these engines such products as are available at home, in order to become independent of foreign imports. The application of coal-tar oils in internal-combustion engines must be regarded as the direct result of this policy, and it is now ready to be transplanted to other countries.

In America there is, apparently, no immediate necessity to take recourse to coal-tar oils as fuels for power generation and for carbureting water gas, since large quantities of crude oil and petroleum are still available. However, it is believed that if the policy of the Standard Oil Company is allowed to continue for a few more years, the supremacy of the United States as an oil-producing country is likely to last only for a very short while. Therefore it would seem to be wise to provide for other sources of supply, which are not under the control of the "oil trust," and for the continuance and stability of which the United States Government is preparing to take adequate measures.

Referring more especially to gas oil, it is a question whether, with the enormous inland consumption (in the United States gas works alone consume 600,000 tons per annum) and the large export (to England, in 1906, 220,000 tons), there will be enough gas oil left available for purposes of power generation at a price which the American consumer is prepared to pay. He certainly will have to pay more for it than the consumer abroad.

Benzol a Substitute for Gasolene and Alcohol

Benzol, formerly called coal benzine or coal naphtha, is a by-product of the coal-tar industries. It is obtained in illuminating-gas works, and in modern by-product coke-oven plants, through fractional distillation of the tar which separates out during the gasification process of the coal, or it is extracted from the gas subsequent to its generation when being cooled. The commercial liquid benzol when heated to 100 degrees Centigrade will deliver 90 per cent. of distillate, distillation beginning at between 80 and 81 degrees Centigrade. It is therefore called benzol of 90 per cent. When purified, it is a colorless liquid hydrocarbon, its specific weight being between 0.879 and 0.883. The freezing point of benzol is below 0 degree Centigrade, and by the admixture of up to 10 per cent. of alcohol or gasolene it can be lowered to 15 and even 20 degrees below zero. Benzol will not mix with water, but it will mix with gasolene, alcohol and other hydrocarbons in any proportion. Its heat value is approximately 10,000 calories per kilogram, or 18,000 B.t.u. per pound,

which is not much lower than that of gasolene, but is much higher than that of alcohol. Benzol is less dangerous to handle than gasolene, because at ordinary atmospheric temperatures it does not volatilize nearly so much as the latter. By mixing with it a like amount of tetrachlorcarbon, benzol can be made perfectly non-ignitable, while gasolene would have to be diluted with a much greater quantity, say one part of gasolene to nine parts of tetrachlorcarbon. Notwithstanding this desirable feature, benzol vapor mixed with air in proper proportions will form an excellent combustible, which characteristic makes it excellent as a fuel for internal-combustion engines. It is superior to gasolene in that higher compression pressures (up to 15 atmospheres) can be used in the engine, producing higher thermal efficiency, while compared to alcohol it possesses, at equal compression pressures, the advantages of higher calorific value and heat density. Benzol is also used for enriching illuminating coke-oven and water gas, and for making air gas. It is mixed with alcohol in proportions up to 10 per cent., in order to cheapen the use of that fuel without harming its desirable characteristics.

Although benzol is dearer than other coal-tar products, such as creosote oil or anthrazen oil, it has found extensive use as substitute fuel for gasolene and alcohol engines of the explosive-combustion type, which employ a vaporizer or carbureter in which a combustible mixture is formed outside the engine cylinder. Almost all automobile and boat motors and all engines of the Otto type, designed for use in workshops, on farms, in pumping plants, etc., can be operated at half the existing expense, if benzol is used instead of benzine or gasolene. For larger engines no alterations are necessary; for small motors a special carbureter is required.

Characterization of Hard-coal Tar By-products

As very little knowledge has been propagated in the United States concerning the physical and chemical characteristics and use of the various by-products which can be obtained from hard-coal tar through fractional distillation, and as the knowledge of novel and cheap sources of fuel is very important for prospective users of oil power, the classification subjoined herewith will be of interest. It gives all tar products which are manufactured and sold on a large scale. The endeavor of the coal-tar industries in Germany is directed toward constantly increasing the quantity and the quality of the cheaper grades of hard-coal tar oils which can be used as fuels for power generation in modern oil engines, in order thereby to become independent of the supply of high-priced oils imported from abroad.

1. *Hard-coal Tar*—Obtained from the destructive distillation of hard coal. By-product of coke oven and city gas works. Characteristics: Specific gravity, 1.08 to 1.20, depending on the kind of coal gasified and on the type of oven used. Is a black, heavy liquid containing from 3 to 5 per cent. of water. Use: From hard-coal tar as the original material are gained the various tar products. It also serves for preserving wooden piles, beams, etc., set in the ground.

2. *Prepared Tar* or *Roof Lack*—A coal tar from which are driven off the water and the light volatiles by distillation. Characteristics: Specific gravity, 1.14 to 1.20. Like No. 1, but free from water. Use: Serves for the manufacture of roof coverings, for their preservation and for the protection of surfaces against the ingress of moisture and putrefaction.

3. *Benzol* (heavy benzine; 90 per cent.)—A colorless liquid. Characteristics: Specific gravity, 0.88. When heated to 100 degrees Centigrade 90 parts distil over. The boiling points are as follows: At 85 degrees Centigrade about 45 to 55 per cent. distils over; at 90 degrees about 75 to 80 per cent. distils over; at 95 degrees about 85 to 88 per cent. distils over; at 100 degrees about 90 to 93 per cent. distils over. Use: It is the original product from which is gained aniline and its derivates. It is used for extraction and solution; also for the carburation of illuminating and water gas, and for the denaturation of alcohol. Lately it is being used as fuel for internal-combustion motors, replacing gasolene and alcohol, costing only half as much.

4. *Toluol*—A colorless liquid. Specific gravity, 0.870. The boiling points are as follows: At 109.7 degrees Centigrade about —— per cent. distils over; at 110 degrees about 2 per cent. distils over; at 110.3 degrees about 35 per cent. distils over; at 110.6 degrees about 89 per cent. distils over; at 110.7 degrees about 92 per cent. distils over; at 110.9 degrees about 95 per cent. distils over. Use: Original product from which are made various colors; also a means for solution and extraction.

5. *Heavy Benzol* (solvent naphtha)—Characteristics: Specific gravity, 0.9 to 0.92. Not so movable a liquid as benzol or toluol; colorless up to reddish yellow. Boils between 100 and 180 degrees Centigrade, sometimes higher. Use: Serves for solution and extraction.

6. *Ergin*—Patent product of the Rütgerswerke in Germany. Characteristics: Specific gravity, 0.9 to 0.916, distilling over between 130 and 190 degrees Centigrade. Color, yellowish or reddish. Use: Fuel for internal-combustion motors, instead of gasolene and alcohol; also mixed with the latter. Serves also for solution and extraction.

7. *Ball Naphthaline*—Pure naphthaline molded into ball shape. Use: Serves for the disinfection and carburation of petroleum, and as a protection against moths.

8. *Naphthaline Scales*—Pure naphthaline sublimated in form of scales. Use: Serves to preserve furs, etc., against insects; also a means of protection against moths.

9. *Anthrazen (40 per cent.)*—Characteristic: Greenish powder. Use: Material from which are made alizarine, and its derivates, in the manufacture of colors.

10. *Denaturation-Pyridine*—Characteristics: Colorless up to reddish-brown liquid; specific gravity, 0.985; has a characteristic bad smell. Boiling point between 95 and 140 degrees Centigrade. At the latter temperature 90 per cent. of the liquid must distil over. Use: Serves almost exclusively for denaturizing alcohol; it is also a means for extraction and solution and forms the original material from which many colors are made. Manufactured in accordance with custom-house regulations, which are the same in substance everywhere else as in Germany.

11. *Carbolic Acid (60 per cent.)*—Characteristics: Colorless or reddish-brown liquid; specific gravity, 1.06; freezing point (determined in accordance with the English method), at or near 16 degrees Centigrade, that is, it must have a content of crystallized carbonic acid sufficient to congeal at 16 degrees Centigrade.

12. *Raw Carbolic Acid (20 to 25 per cent.)*—Characteristics: Specific gravity, 1, sometimes less; contains about 20 per cent. cresyl acids and about 5 per cent. bases (called pyridine bases of high boiling point, the latter lying between 125 and 225 degrees Centigrade). Use: Disinfecting liquid used in sewers.

13. *Impregnating Oil*—Characteristics: Dirty-green or dark-brown liquid; specific gravity, 1.04 to 1.1; boiling points between 150 and 300 or 350 degrees Centigrade, according to the specific gravity. Cresyl acids, 8 to 15 per cent. Use: It is manufactured in accordance with the regulations of the authorities and serves for impregnating railway sleepers, telegraph posts, beams, piles, woods used in water-works construction, the lower part of vine stems, etc.

14. *Wash Oil*—Characteristics: Brown or dark-brown liquid; specific gravity, 1.04 to 1.05; boils between 200 and 300 degrees Centigrade. The distillate must not separate out naphthaline at — 15 degrees Centigrade. Use: Serves for absorbing benzol gas from coke gas, which is generated when coking coal; it is used in coke-oven plants which recover benzol in addition to ammonia and tar.

15. *Tile-press Oil*—Characteristics: Dark-brown liquid; specific gravity, 1.09 to 1.11. At between 220 and 300 degrees Centigrade about 40 or 50 per cent. distils over. Use: In the manufacture of tiles.

16. *Carbolineum, Light*—Characteristics: Reddish-brown or black-brown liquid; specific gravity, 1.09 to 1.105; boils similarly as No. 15. Use: For impreg-

nating and painting surfaces to prevent putrefaction; also as a protection against insects.

17. *Carbolineum, Heavy*—Characteristics: Oil of low viscosity, color like No. 16; specific gravity, 1.12 to 1.13; between 280 and 360 degrees Centigrade about 65 per cent. distils over. Use: Acts similarly to No. 16, but more intensely, because on account of the higher boiling point it is less volatile. It stays better in the impregnated wood, and after some time is transformed to rosin. With the exception of No. 18, it is the best product for impregnation that is gained from coal tar.

18. *Anodor*—Characteristics: Patented by the Rütgers works in Germany. It possesses all the good qualities of heavy carbolineum, but is superior in viscosity and smells less strongly than the latter. Use: For painting rooms, floors and other places where the tar-oil smell of carbolineum and of the other light impregnating oils is objectionable.

19. *Absorption Oil*—Characteristics: Brown or dark-brown tar oil free from naphthaline; specific gravity, 1.12. Up to 270 degrees Centigrade about 7 per cent. distils over. The constituents which distil over between 200 and 270 degrees must not separate out naphthaline when cooling. Use: Serves for absorbing naphthaline from illuminating gas. Naphthaline, being apt to clog the gas pipes, must be removed. Since absorption oil when used alone is apt also to separate out the benzol content from the gas, 4 per cent. of benzol is added to it so that this drawback is eliminated.

20. *Tar Oils for Various Purposes*—To this class belong oils having a specific gravity of from 1.04 to 1.11. They possess indefinite contents of acids and of bases; for instance, blue vapor oils, which serve for coloring roofing tiles. They are also used as fuel oils for firing boilers and in metal-smelting furnaces.

21. *Steel-works Tar*—Characteristics: Black and heavy liquid; specific gravity, 1.2. Between 290 and 350 degrees Centigrade 32 per cent. distils over. Use: Employed in the manufacture of linings for bessemer converters. The material used is a mixture of ground dolomite and steel-works tar.

22. *Pavement Cement or Asphaltum*—Characteristics: Pitch-like, black mass. Use: For filling the interstices between the edges of wooden and granite paving stones.

23. *Pitch (Coal-tar Asphaltum)*—Characteristics: Black, amorphous mass; its fracture shows a brilliant surface. Melting point between 50 and 100 degrees Centigrade. The main quantity of it, which is used in the briquet industry as binding material, is manufactured for a melting point of about 60 degrees Centigrade. Contents of carbon, about 23 per cent. Generally three kinds of pitch are made: hard pitch, with a melting point between 70 and 100 degrees Centigrade; medium-soft pitch, melting point at about 60 degrees; and soft pitch, with melting point at about 55 degrees. Pitch for cartridge factories has a melting point beyond 85 degrees Centigrade. Use: In the manufacture of briquets, of lack and for insulating purposes, such as where cork pieces are soaked with pitch and used as heat insulators, etc.

24. *Iron Lack (Oil Lack)*—Characteristics: A light and a heavy quality of oil are manufactured; the first dries quickly; specific gravity, from 1.13 to 1.14; after drying it becomes brittle. The second dries slowly; specific gravity, from 1.14 to 1.15; after drying it is less brittle; surface, brilliant. Use: For painting tanks, iron masts and iron parts of various kinds.

25. *Ammonium Sulphate (Pure)*—Characteristics: White or dirty-gray salt. Use: Employed in large quantities in agricultural pursuits.

26. *Carbolcalcium*—Characteristics: Red powder, smells like carbolic acid. Use: for disinfecting public places, etc.

27. *Pure Naphthaline*—Characteristics: Freezing point, between 79.5 and 79.8 degrees Centigrade; a kernely, white mass. Use: Material from which are made several products which are used in the manufacture of colors; serves chiefly to make artificial indigo. Also used extensively for preserving skins and furs against putrefaction and against destruction by insects.

December Meeting of the A. S. M. E.

The 54th annual meeting of the American Society of Mechanical Engineers will be held in the Engineering Societies building at 29 West Thirty-ninth street, New York, December 3-6, 1907. Symposiums on foundry practice, giving the experiences of prominent men in that work, have been arranged. The specific heat of superheated steam will be taken up, and a very important and exhaustive work by a professor of engineering at Cornell will be presented. The utilization of low-grade fuels in gas producers, combustion control in gas engines and tests of producer-gas engines will be given attention, and other live topics, such as industrial education, power transmission by friction driving and cylinder-port velocities will be discussed.

All of these subjects will be treated of by prominent engineers of Europe and America, professors of universities and men eminent in the particular work of which they write. The committee has in hand the arrangement of an interesting excursion for Wednesday afternoon, December 4.

The specific heat of flue gas may be taken as 0.24.

The Gas-engine Cycle

By W. H. Booth

In the two-stroke-cycle engine there must necessarily be cooling of the rods and glands, but it will help to a general comprehension of the subject if one remembers that, as is also the parallel case with superheated steam, the rods enter the stuffing-boxes from the exhaust temperature and leave the stuffing-boxes when moving into the high temperature of either superheat or burning gas; and, further, that the part of the rod which is most exposed to high-temperature steam or burning gas is that which last enters the stuffing-box and then only at the slow speed due to the then position of the crank near the dead center.

But there is a mechanical reason in favor of the two-stroke-cycle engine on which emphasis might be laid, if necessary, to strengthen an already very good case. In the four-stroke-cycle engine the stress in the piston-rod is reversed in direction just as it is in the double-acting engine, but in the double-acting engine useful work is being done; whereas in the single-acting four-stroke-cycle engine the piston is pushed back by the rod solely for the purpose of exhausting a few ounces of burned gases, and it is rapidly reversed in direction and dragged out again by the crank-pin, solely in order that it may pull in a few ounces of fresh air and gas. This is employing a ponderous and very costly mechanism in order to perform a duty that can better be performed by light machinery. The single-acting engine is made double size and this size is again doubled for the sake of the four-stroke-cycle principle.

The four-stroke-cycle principle is all very well in relation to little engines such as all engines were when the four-stroke-cycle engine first was made a practical affair. Some people seem to think that four-stroke working constitutes a "principle." It is a *modus operandi* only. Compression of the working stroke is a matter of principles, but the arrangement of the supply of gas and air is a mere matter of design, yet it is of very great importance, for it involves commercial questions and costs of serious value.

In England, where the Diesel engine has come into considerable use, the supply of the working charge to the cylinders of several engines has to some extent been made a matter common to several engines, so far at least as they all pump the air, for spraying the fuel, into a common system, and from this it is but a step to a general central supply of air and of gas from a central reservoir or reservoirs supplied by pumps specially devised for this class of work, namely, the supply of large volumes at low pressures.

In many installations of blast-furnace gas engines, the scavenging of the working cylinder is done by air from the blowing tubs and what is needed in a large gas-power installation is something in the nature of a large and light blowing tub or bellows or a positive blower. In any case both the air and the gas supplies may be worked by electrical means where convenient to do this. There are of course, very cogent arguments advanced against the two-stroke-cycle engine.

Arguments against the Two-stroke Engine

There is a double number of explosions in the cylinder end in a given time, and this may render the cylinder so much hotter that it cannot be kept sufficiently cool to work with the desired ratio of compression. The creation of this double quantity of heat in the same cylinder capacity necessarily diminishes, also, the cooling opportunities of the cylinder, and it may be true that at present a four-stroke-cycle engine is the leading engine, or is so claimed to be. But this is not necessarily a matter of principle. It may, if true, be due to a very good design, for it is not always that the machine on the best principles is always best designed, and an inferior principle may appear best in work, because the best has been done to make it a practical success.

But it is obvious that the heavy gas engine is a wasteful piece of machinery as ordinarily built, for it is a machine capable of taking pressures measured in hundreds of pounds per square inch and yet its mechanical efficiency is seriously reduced by giving half the engine nothing to do, though in the single-acting engine the front end of the cylinder has been used to supply scavenging air. Then the back end is made to do light work, so light that it could be done by a fan or bellows, and thus one-half the capacity of this end of the engine is thrown away as regards power production.

Every motive-power engine has a certain mechanical efficiency. The best steam engines are believed to have a mechanical efficiency of 94 per cent.; they throw away 6 per cent. in internal work and friction. The single-acting gas engine, which has only one working stroke in four, ought to throw away about four times 6 per cent., retaining a mechanical efficiency of 76 per cent., and this is probably very nearly the truth. A higher efficiency is claimed for some of them, but this may perhaps be very properly allowed, and indeed may be expected as any property due to the higher mean pressure would naturally tend to greater mechanical efficiency, because for a given power the cylinder dimensions would be less, or the volume swept by the piston would be smaller. So great is the mechanical loss that it could not possibly be continued without attracting endeavors to remedy it by the development of double-acting and independent pumps for the movement of gas and air at low pressures.

As to the necessity for stratification, or the interposition of a layer of air between the charge and the exhaust port, those who uphold the four-stroke-cycle practice urge that gas is very apt to escape at the exhaust ports. Those who argue this way are men of ability and of experience and therefore entitled to be heard. We must believe that they have experienced the troubles that induce them to stick to the four-stroke-cycle engine, though we are perhaps entitled to think that it is simplicity they are really bent upon, no bad thing in its way but something that may be too dearly bought, especially if simplicity can be had with the two-stroke cycle also. Indeed, may it not be urged that, with independent air and gas pumps arranged to serve a whole battery of engines, the simplicity is really greater than with the four-stroke-cycle engine?

Worst Mechanical Defect of the Four-stroke Engine

Perhaps, however, the worst mechanical defect of the four-stroke-cycle engine is the continuous variation in the duty of its mechanism. In steam engines do we not always see to it that the initial pressure in the cylinder shall be more than sufficient to accelerate the piston and other moving parts, so that there shall be no tension on these during an out stroke and no knock as the result of catching up slackness? In the gas engine this knock is not often heard, but there is always the necessity of caring for it, the necessity of keeping all bearings closer, perhaps, than is desirable, that is, desirable for minimizing the risk of hot bearings due to lubrication difficulties. Do not gas-engine builders themselves recognize this fault or danger by placing two cylinders in line, so as always to have an explosive stroke to give the acceleration forces?

To revert to the question of gas escape by the exhaust ports; this brings up for consideration the means that may be adopted for preventing it. One of them is to employ longer cylinders, so that there may be a better opportunity to keep back the gas. If escape so regularly occurs, it must be due to the very serious turmoil in the cylinder. No doubt the entry of air is far from quiet and a cylinder is full of eddy currents and vortices which catch up the gas and sweep it through the cylinder. An endeavor has to be made to check these violent disturbances. For the fact of the universality of the short cylinder there may be some good reason. Just as we find that the steam engine has fallen short of success unless it has been of a certain standard general construction; as the rotary engine has failed to achieve commercial longevity, from certain inherent defects in its mechanical constitution, so the gas engine may require to have a short stroke. On the other hand, it is not yet fully developed, and it may be that its best mechanical and physical development will yet find it of longer cylinder proportions and that it will get over the leakage difficulty. But at the moment the leakage of gas appears most certainly to be safeguarded by commencing its inlet only after the exhaust port has closed. This, of course, demands that the gas shall have a pressure somewhat higher than otherwise necessary, in order that it may enter the cylinder against the slowly increasing pressure due to the progress of the compression.

Such are the points that still await solution in the problem of the gas engine and bear particularly on the vexed question of the relative merits of the two- and four-stroke cycles. It seems historically probable that the four-stroke-cycle engine is the parallel of the early steam engine which gradually assumed the present universal two-stroke double-acting form. This latter is a form easily possible because the working fluid enters from a storehouse of the fluid in the boiler. Similarly the gas engine requires to be fed with its working fluid from a pressure or storage system. For large stationary plants, capacious gas and air holders filled by a continually running pumping plant would appear to be in some cases desirable.

Fly-wheel Explosions

On October 5 a 16-foot fly-wheel in the power house of the Carrollton (Mo.) Water, Light and Power Company burst and caused damage amounting to $7000.

On October 14 a fly-wheel on one of the engines of the Menasha Paper Company, at Ladysmith, Wis., was wrecked in consequence of the governor belt running off. One piece of the wheel went through the roof.

The chief engineer of the Greenfield (Mass.) Electric Light and Power Company informs us that the "fly-wheel wreck" at that plant, reported in the October number, was nothing but a slight accident which damaged the engine only, to an extent of a few hundred dollars.

The Westinghouse-Parsons turbine, a test of which was published in the November number, and which developed a kilowatt-hour on a trifle less than 14.9 pounds of steam, earned for its builder a bonus of about $25,000, the guarantee having been 15.9, with a bonus for a lower consumption. This steam consumption figures less than one and one-half pounds of coal per kilowatt-hour.

The Hydraulic Elevator—XII

A Description of the "Pushing" Type of Horizontal Elevators, Details of Operation and Construction of Valves and Parts

BY WILLIAM BAXTER, JR.

The main difference between vertical and horizontal hydraulic elevators is that the first-named have vertical lifting cylinders, while the latter have horizontal cylinders. The valve mechanism of a vertical machine can be used with perfect success on a horizontal machine, and in fact it has been so used in several instances, but the best type of horizontal machines have a valve mechanism of distinctive design; although the principle of operation is the same as in the vertical machine valve-gears described in previous articles.

Horizontal hydraulic elevators are divided into two classes known as the pushing and pulling types. In this article will be described the Crane pushing-type elevator, built in Chicago by the Crane Company, now a part of the Otis Elevator Company. This is one of the most extensively used elevators of this character. The general arrangement is clearly shown in Fig. 118. It will be seen that the rear end of the cylinder is adjacent to the elevator well, and that the pressure water forces the piston toward the opposite end, which results in pushing the traveling sheaves away from the stationary sheaves, thereby drawing the lifting ropes downward and lifting the car. Therefore, the "pushing" type of elevator derives its name from the fact that the cylinder is placed between the stationary and traveling sheaves and "pushes" them apart in order to raise the car. The steam pump draws water from the open tank shown and forces it into the pressure tank, whence it passes to the rear end of the cylinder, between the piston and the back head, and forces the piston forward. On the return stroke the water in the cylinder is discharged into the open tank through the discharge pipe shown entering at one side of the tank. The main valve through which the water enters and leaves the cylinder is located at *K*, and is automatically operated by the movement of a pilot valve located at *L*, the latter being actuated by the rocking of the shaft *M* through the movement of the rods *m m*, which are connected with a running-rope system operated by the car lever. In design the main valve and the pilot valve differ from those described in previous articles treating of vertical elevators, but the principle of operation is identical. An automatic stop-valve is located at *R*, between the main valve and the cylinder, as is the case in vertical-elevator construction. It is actuated by the mechanism shown at *N*, which in turn is set in motion by the movement of the traveling-sheave crosshead.

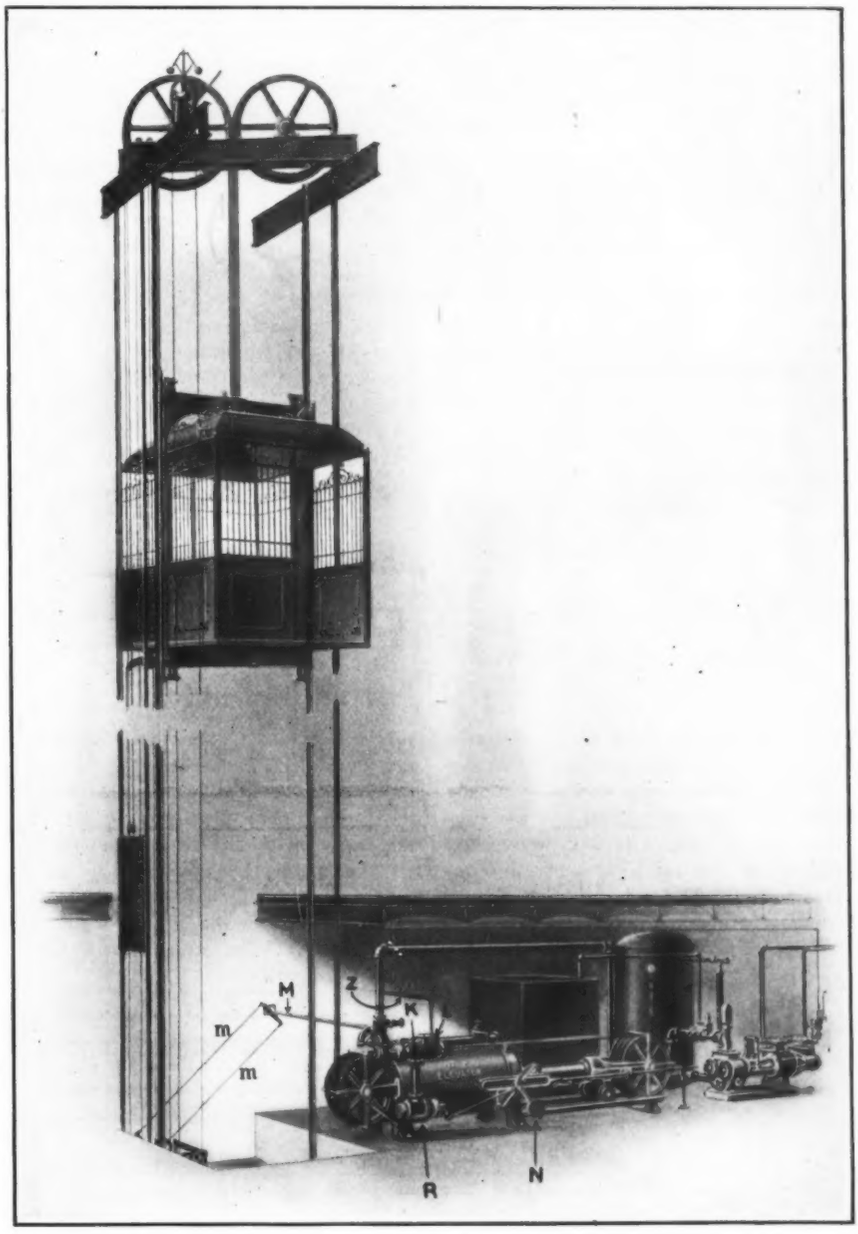


FIG. 118

The Operation in Detail

The operation in detail can be more clearly explained in connection with Figs. 119, 120 and 121, the first being a side elevation, the second a plan view, and the third a vertical cross-section of the cylinder, piston, sheaves and connecting parts. In Fig. 119 it will be seen that if the car lever *S* is moved in either direction the rods *m m* will rock the shaft *M* and actuate the pilot valve through the medium of the valve-rod *L'*. The movement of the pilot valve opens or closes

the main valve *K*, so as to let water in or out of the cylinder, according to the direction in which the lever *S* is moved. When the car reaches the upper end of course, will stop the movement of the piston, and of the car. If the car is coming down the piston will be moving to the left, and if the operator does not re-piston end of the plunger *E* and a similar ring in the crosshead *D*, while attached to the front cylinder-head *G* is a strong buffer frame *I*. If the car overruns its

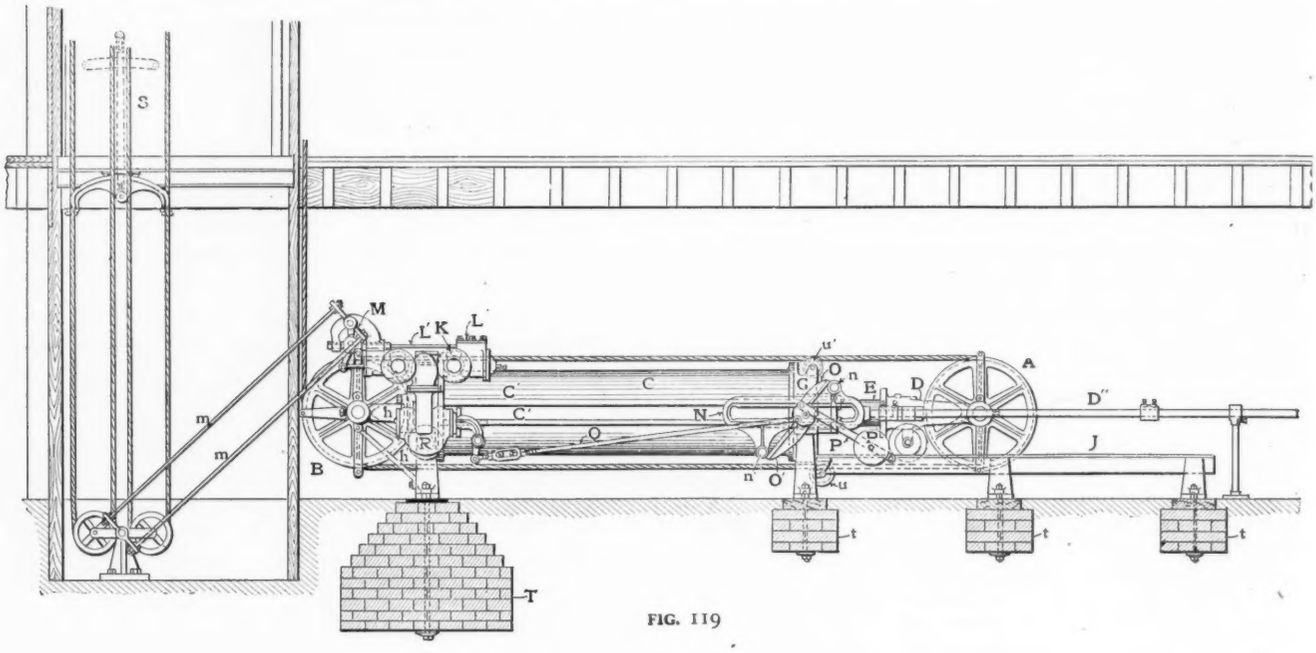


FIG. 119

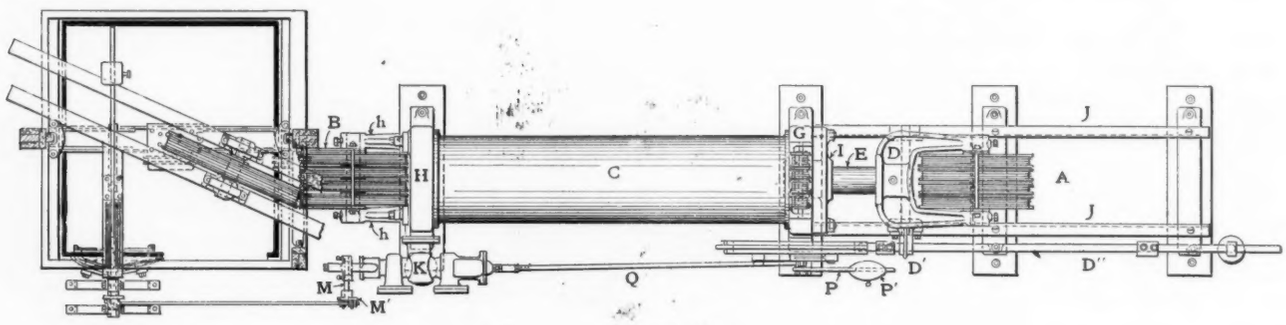


FIG. 120

the well, if the operator does not return the lever *S* to the stop position the frame *N* will be carried to the right by the movement of the crosshead and the projecting arm *D'* Fig. 120, will strike stop mounted on the rod *D''*, which is connected to the right-hand end of the frame. This movement of the frame *N* will cause a roller at *n'* to strike the lever *O'*, which turn the lever *S* to the stop position when the lower floor is reached, the arm *D'* on the crosshead *D* will strike the stop on the rod *D''* near the frame *N* and carry the frame to the left, so that the arm *O* will be moved by the roller *n* and, as before, the rod *Q* will actuate the stop-valve and prevent the flow of water from the cylinder. The stop-valve *R* can be normal travel at either end, the rubber ring at that end will strike the buffer *I* and prevent the car going farther in that direction. The adjustment of these parts should be such that the car and counterbalance weights cannot strike the overhead beams, in case the automatic stop gets out of adjustment and fails to act in time. With proper adjustment there will be no

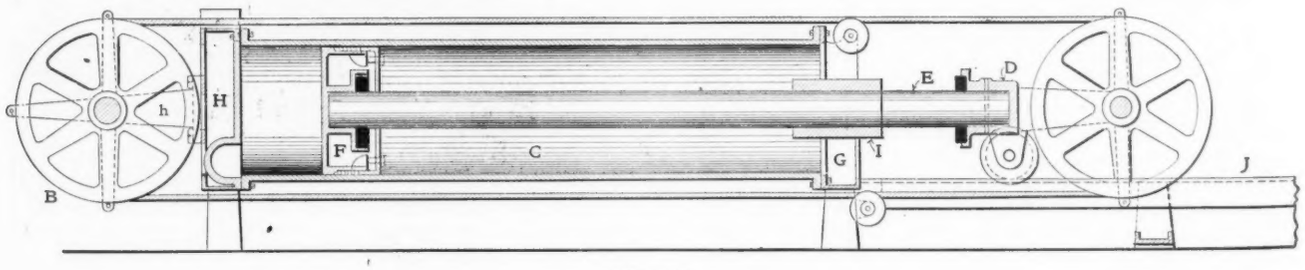


FIG. 121

will move to the right and pull the rod *Q* in the same direction; and this action will close the stop-valve *R* and stop the flow of water into the cylinder, which, of adjusted to act at any time desired, by means of the stops on the rod *D''*.

Referring to Fig. 121 it will be seen that there is a rubber ring around the contact with the buffer *I* at all, but the stretching of the ropes may disturb the adjustment, when it should be restored to normal condition by the means to be ex-

plained. The buffer *I* and the back cylinder-head *H* are tied together by means of four strong bolts which extend the length of the cylinder, there being two on each side. The front bolts are shown at *C' C'*, Fig. 119. The traveling-sheave crosshead is provided with rollers which run on the tracks *J J*, their purpose being to keep the piston plunger in line with the cylinder. The stationary sheaves at the back of the cylinder are mounted upon and revolve with a shaft held in position by the frames *h h*; and to enhance the strength of the support these frames are braced by wrought-iron rods *h'*, as shown in Fig. 119. The rear end of the cylinder is secured to a heavy foundation *T*, the weight of which is sufficient to overbalance the maximum pull on the lifting ropes. The foundation piers at *t, t, t* are not as large, being intended simply to insure alinement.

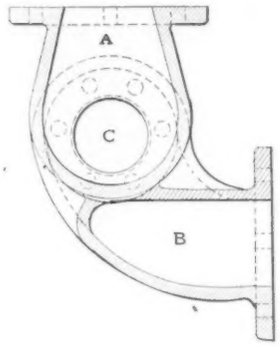


FIG. 124

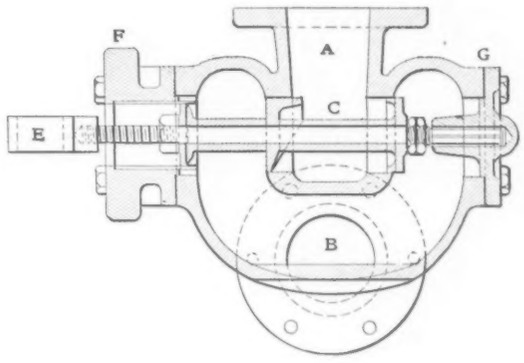


FIG. 125

The Main and Pilot Valves

The operation of the main valve and the pilot valve may be understood from Figs. 122 and 123, the first a vertical elevation in section and the second a plan view. In Fig. 122 *I* and *J* are cup packings. The pressure water enters the valve chamber through the port *I'*, and if there is no pressure back of the piston *G* the valve will move to the left, because the diameter of *I* is larger than that of *J*. On the other hand, if pressure water is admitted between the piston *G* and the cylinder-head the valve will move to the right, because the pressure on *G* will counterbalance that on *I* and the pressure on *J* will force the latter to the right. In Fig. 118 it will be seen that the pipe *Z* connects the pressure pipe with the pilot-valve chamber. This pipe connects with the port *K*, Fig. 122, therefore if the rocking lever *M'*, Fig. 119, is actuated so as to move the lever *C*, Fig. 122, to the right, the pilot valve will be shifted to permit the pressure water in the port *K* to pass through the port *L* to the back of the piston *G*. This will force the main valve to the right, connecting the center port *H* with the discharge port *G'*. In this manner the water will be discharged from the cylinder, the piston will move toward the rear and the car will descend. If the lever *C* is moved to the left, the pilot valve *F* will be shifted to allow the water behind the piston *G* to run out through the port *L* into and through the port *M* to the discharge pipe.

This movement of the main valve will carry the piston *I* to the left so that pressure water from *I'* will pass to and through *H* to the cylinder, forcing the piston forward and lifting the car. The lever *N'* is pivoted at the point *O*, in the circular frame *D*, and its upper end is connected with the pilot-valve stem *E'*; consequently, when the main valve moves to the right it carries the pilot valve to the left. When the pilot valve is moved to the right by the car lever, the main valve is also moved to the right through the pressure water passing from the port *K* through the port *L* to the rear end of the valve chamber; so, as soon as the main valve begins to move it shifts the pilot valve back to the stop position, the action being precisely the same as in all the

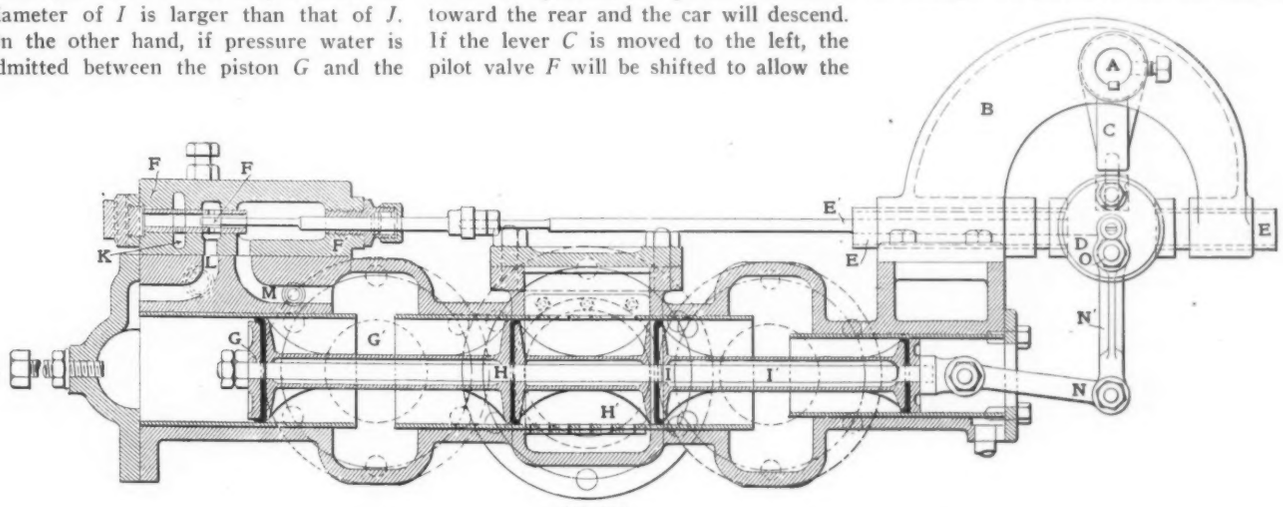


FIG. 122

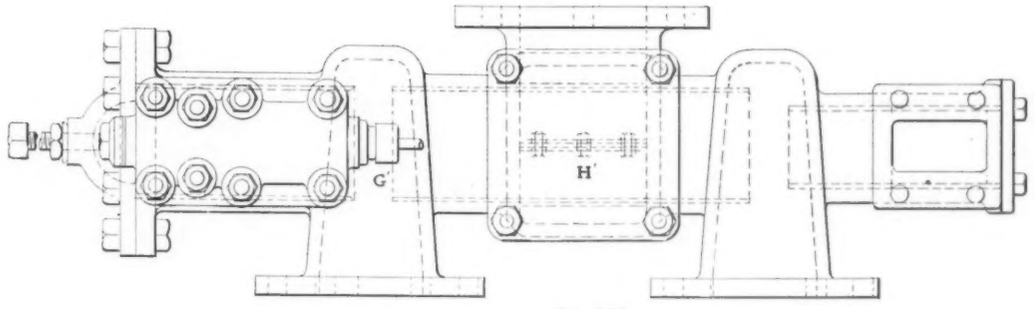


FIG. 123

pilot-valve gears previously described. In Figs. 122 and 123, for the purpose of simplifying the drawings, the flanged outlets of the ports G', H' and I' have not been shown in their true positions. The outlets G' and I' may be on the same side of the valve chamber, or on opposite sides, according to which affords the best piping design. The center outlet H', however, is always placed on the under side, so it can be run down to the top of the

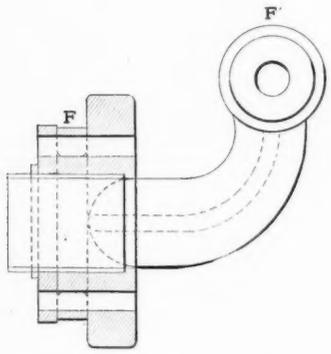


FIG. 126

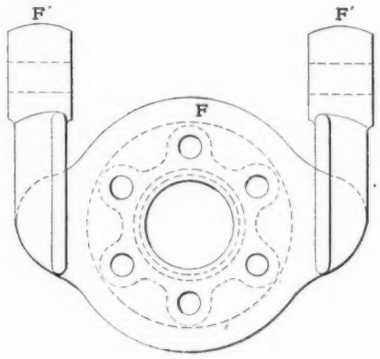


FIG. 127

FIG. 128

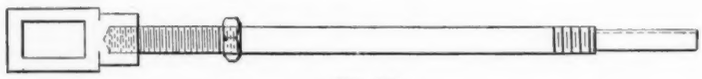


FIG. 129

valve R is made clear in Figs. 124 and 125, the first being a vertical section, through the casing alone, at right angle to Fig. 125, and the second a vertical section through the valve and casing on a line parallel with the axis of the cylinder. The construction of the valve-rod is shown in Figs. 128 and 129. The end of the lever a', Fig. 119, is located within the square opening shown in the end of the valve-rod, Fig. 129, which allows free-

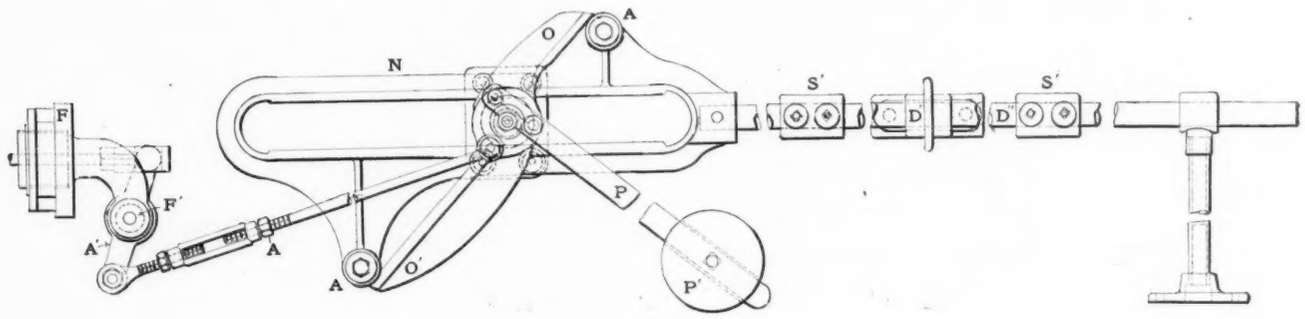


FIG. 130

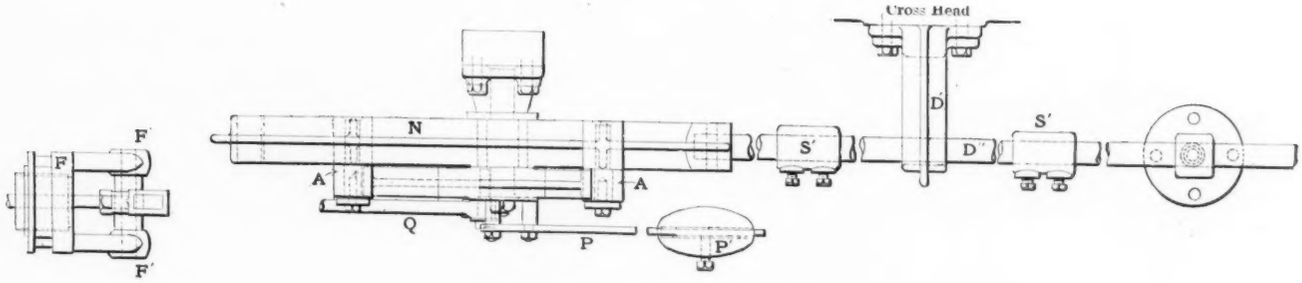


FIG. 131

stop-motion valve, as will be readily understood from reference to Fig. 119.

The Automatic Stop-valve

The operation of the automatic stop-valve R is made clear in Figs. 124 and 125, the first being a vertical section, through the casing alone, at right angle to Fig. 125, and the second a vertical section through the valve and casing on a line parallel with the axis of the cylinder. The construction of the valve-rod is shown in Figs. 128 and 129. The end of the lever a', Fig. 119, is located within the square opening shown in the end of the valve-rod, Fig. 129, which allows free-dom of movement for shifting the valve in either direction. The weight P' on the lever P, Fig. 119, is the medium by which the valve is pulled open (or to the left, in Fig. 125), and the rocking of the lever $O\,O'$ by the action of the frame N forces the valve to the closed position (or to the right, in Fig. 125). The piston of the valve C, Fig. 125, which closes the passage, is tapered so as to gradually stop the flow of water and prevent the sudden stoppage of the car. Referring back to Fig. 119, it will be noted that when the elevator is at either end of the well the valve R is closed; therefore, unless its construction permits water to leak by, the car cannot be started. As a matter of fact, the valve does not fit perfectly, but leaks just enough to permit the piston to move slowly in starting from either end. This not only prevents making a too sudden start, but it also prevents sudden stopping, because even after the valve has been closed some water can pass through it; but not enough to permit the elevator to run at anything like full speed.

Figs. 126 and 127 show the construction of the front head of the automatic stop-valve chamber. The projecting brackets $F'\,F'$ support the stud on which swings the actuating lever a', Fig. 119. This head has an inner lining within which the outer piston of the stop-valve works, as shown in Fig. 125. As the object of this piston is simply to make a tight joint, an ordinary stuffing-box could be used for the purpose, but a piston with a cup packing gives better satisfaction; also, the pressure on this piston helps to force the valve outward, permitting the reduction of the size of the weight P'.

The construction of the automatic stop-valve shifting mechanism is shown in Figs. 130 and 131, the former being a side elevation corresponding to Fig. 119 and the latter a top view, corresponding with Fig. 120. In these drawings it can be seen that O and O' are ends of the lever which operates the stop-valve. This lever is

mounted on a stud carried by a frame bolted to the side of the front cylinder-head, the frame also serving as a guide for the sliding frame N on which are carried the rollers a which actuate the lever. The front head of the stop-valve is shown at F. The stops S' S' are adjusted on the rod D'' so that they will be struck by the arm D', projecting from the side of the traveling-sheave crosshead, at the right instant to bring the car to a stop just beyond the top or bottom floor of the building.

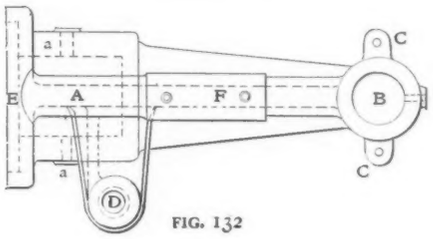


FIG. 132

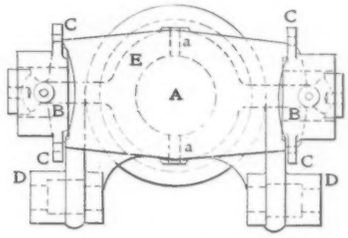


FIG. 134

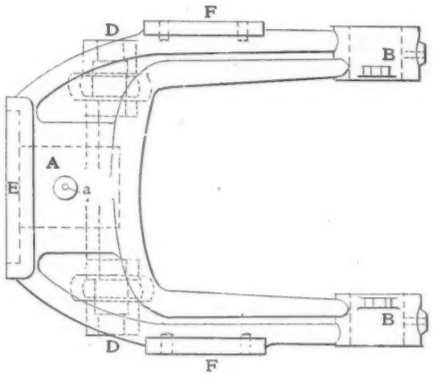


FIG. 133

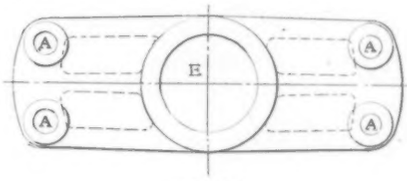


FIG. 137

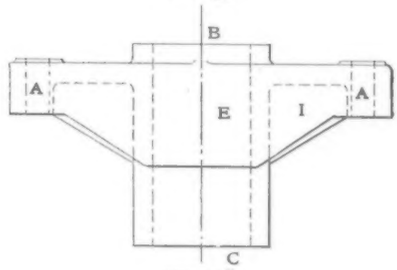


FIG. 138

Construction of Other Parts

The traveling-sheave crosshead is shown in Figs. 132, 133 and 134, which are side, top and end views, respectively. The piston plunger is secured in A, and the shaft on which the sheaves revolve is held in the ends B B by means of set-screws. The lugs C C are provided to hold a cable guard, which is shown in Fig. 118. The office of this guard is to hold the cables against the sheave surface, in event of their becoming slack from any cause. The rollers upon which the crosshead moves are mounted on studs fastened in the lugs D D. The rubber buffer already mentioned is located in the recess E. To prevent the piston plunger from working loose a pin is inserted in the holes a a, as shown in Fig. 121. The operating arm of the stop-motion mechanism of Figs. 130 and 131 is bolted to the seat F. There are two seats, one on each side, to permit placing the stop-motion to suit the convenience.

The piston is shown in Figs. 135 and 136, the latter being a section parallel with the axis. As indicated, the packing is to be compressed by means of a ring A, by tightening the bolts B B. The buffer ring is held in a circular depression surrounding the plunger, at C, the depression being somewhat larger in diameter than the ring, to give the rubber expansion room when it is acted upon by the buffer.

The construction of the buffer is shown in Figs. 137 and 138. As stated, the buffer is held against the outer surface of the front cylinder-head by four strong bolts which pass along the sides of the cylinder to the rear cylinder-head, the bolts being shown in Fig. 119. The center hub is bored to fit the piston plunger at E, and the ends A A are faced to fit abutting seats on the outer surface of the cylinder-head. The end B of the center hub is located next to the crosshead, the other end facing the cylinder.

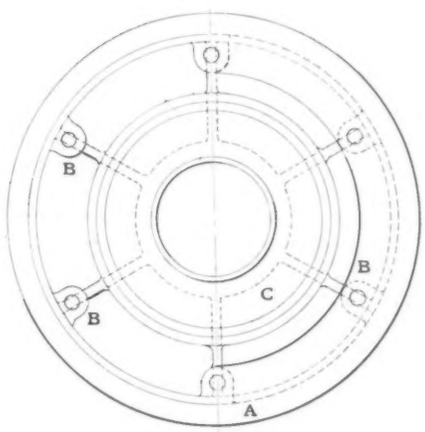


FIG. 135

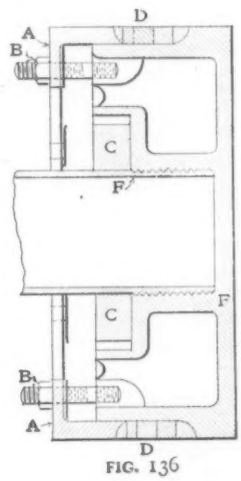


FIG. 136

The construction of the front cylinder-head is shown in Figs. 139 and 140, the first being an end view and the second a side elevation. The head is secured to the cylinder flange by bolts passing through the holes a a. The supporting frame of the stop-motion mechanism is bolted to one of the faces B B. The guides upon which the crosshead rollers run are fastened to the lugs C C. These guides are made of heavy-section angle iron. The lugs D D, located just below the lugs C C, support a shaft upon which are mounted the shell sheaves for the lifting ropes running under the cylinder, as shown at u, Fig. 119. The lugs E E on the top of the head hold a shaft on which are mounted the small sheaves (u' Fig. 119) which support the lifting ropes running over the top of the cylinder-head. The large holes A A are for the long bolts that hold the buffer against the head, and, as is apparent in Fig. 140, the part through which the holds extend has been turned to form a raised seat to hold the buffer square with the cylinder, and prevent cramping the piston plunger.

The back cylinder-head is shown in Figs. 141 and 142. This head is also provided

with four large holes *A* to receive the long bolts that clamp the buffer to the front cylinder-head. From this construction it is evident that whenever the piston strikes the buffer, the strain is not impressed upon the cylinder, but is carried by the bolts. The stop-motion valve *R*, Fig. 118, is connected to the inlet *R*, Fig. 141, a port *R'* being located in the body of the head. The lugs *B B* are anchorages to hold the ends of the lifting ropes, two lugs being provided so that the ropes may be attached at whichever side may be necessary.

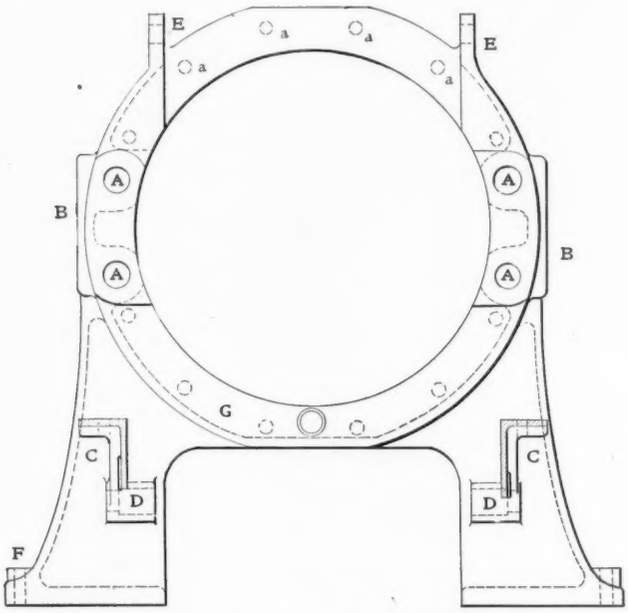


FIG. 139

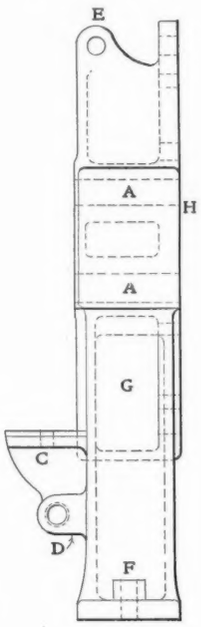


FIG. 140

Steam-turbine Output

A useful rule of thumb in turbine work is the following:

Turbine brake horse-power =

$$\sqrt{2} \times K.W.;$$

Turbine ind. horse-power =

$$1.5 \times K.W.,$$

K.W. being the kilowatts delivered at the terminals of the generator and "ind. horse-power" being that which corresponds to the indicated horse-power of a reciprocating engine. The square root of 2 = 1.414.

That the industrial future of a nation is largely dependent upon the placing of the control of its natural resources in the hands of the public, is becoming more and more recognized, and many nations have already commenced to act on this principle. The *Cologne Gazette* states that Switzerland has decided to place the control of the country's water power in the confederate government, for the purpose of safeguarding the public's right in these natural resources, as well as insuring the future industrial development of the country along equitable lines.—*Machinery.*

Dynamo and Motor Troubles

By GEORGE W. MALCOLM

SPARKING

Sparking at the brushes is one of the commonest dynamo and motor troubles, notwithstanding the large amount of attention that scientists have given to the analysis of the principles of commutation and the resulting excellence of modern designs.

No matter how beautifully a dynamo or motor may operate when first sent out from the factory, hard service and, what is worse, careless handling will inevitably develop sparking at the brushes.

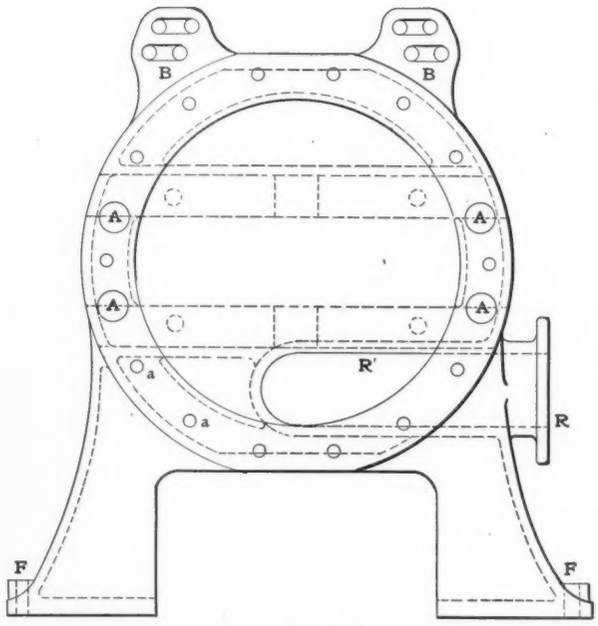


FIG. 141

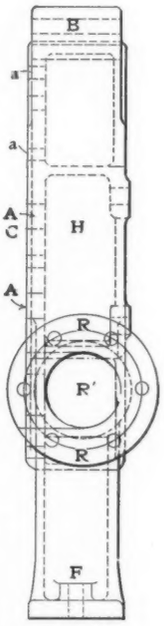


FIG. 142

Sparking may result from one or more of the following causes:

The brushes may not be set exactly at the point of best commutation. With a good make of dynamo or motor, not overloaded, a position can always be found where there is no perceptible sparking, and at this point the brushes should be set and secured.

The brushes may be wedged in the holders, if they be of the box type.

The brushes may not be fitted to the circumference of the commutator.

The brushes may not bear on the commutator with sufficient pressure.

The brushes may be burnt. This usually indicates that the "pigtail" between brush and holder is not fastened securely.

The commutator may be rough; if so, it should be smoothed off.

A commutator bar may be loose or may project beyond the others.

The commutator may be dirty, oily or worn down so far that the bars are mechanically unstable.

The machine may be overloaded.

There may be an open circuit or loose connection in the armature, which would cause a long bright spark apparently extending around the commutator and which leaves a scar at the point of open circuit.

There may be a short-circuited coil in the armature; this causes a heavy intermittent spark to appear at the brushes and is very destructive to the commutator. A short-circuit is easily discovered by shutting down the machine and feeling over the winding with the hand. An excessively hot spot will indicate the point of trouble.

The brushes may not be equally spaced around the commutator. Their spacing can readily be checked by marking their

position on a strip of paper which may be placed around the commutator, under the brushes. Any inaccuracy in spacing should be corrected.

Remedies for such of these causes of sparking as are not suggested are obvious. If the brushes are burnt on the ends they must be ground down to fit the commutator as already described.

Failure to Excite

Failure to excite itself is a common trouble with new generators and occasionally with those which have been in operation and were all right when shut down. If upon starting the generator it fails to show any voltage when running at normal speed, examine the field circuit to see if it is not interrupted by an open switch, a poor connection, or a burnt-out rheostat. A magneto may be used to test the field circuit, but it is possible that the machine will not ring through the high resistance of the whole field. In this case, sections of the field winding may be taken, say one coil at a time, going completely around the field magnet.

If the field and armature circuits are complete, the fault may be due to a reversed connection. If this is so it can be shown very simply by opening the shunt field switch. If the voltage rises slightly and then falls again upon closing the switch, it is pretty certain that the residual field magnetism is opposed by the shunt field winding and the connections of the latter are wrong. Reverse these connections and the generator should not give further trouble.

It may, however, be necessary to excite the generator from some other source. Calling the generator it is desired to excite No. 1 and the other machine from which current is to be drawn No. 2, the following procedure should be followed: Open all switches and remove all brushes from generator No. 1; connect the positive brush-holder of No. 1 directly with the positive brush-holder of No. 2, and connect the negative brush-holders together through a 5-ampere fuse and a switch. Close the circuit. If the shunt winding of generator No. 1 is all right, its field magnet poles will show considerable magnetism. If possible, reduce the voltage of generator No. 2 before opening the circuit again, but if this cannot be done throw all of the rheostat resistance in the field circuit of No. 1 and then open the connection slowly.

If it is impossible to obtain current from a second generator, excitation may be accomplished with a strong battery by connecting the carbon or copper terminal of the battery to the positive brush-holder of the generator and the other battery terminal to the negative brush-holder.

A simple method for getting a compound-woumd generator to "pick up" is to short-circuit the armature through the series field winding with a fuse in the circuit having a capacity about equal to half that of the machine. If the fuse is not melted, there is a defect in the armature. If the fuse is melted, and the machine still refuses to excite itself, the defect must be in the shunt field winding.

Grounds

Grounds may occur on the line from which power is secured or to which it is supplied, or within the machine itself. To test for a ground connect in series a number of incandescent lamps the combined voltages of which are equal to the voltage of the machine. Place one terminal of the lamp-bank on first a positive then a negative brush of the machine, the other terminal being well grounded. If the lamps light up, there is a ground on the line. If, however, the frame of the machine is not insulated from the ground, this method will not distinguish between a ground on the line and one within the winding of the machine. If the frame be insulated from the ground and the terminal previously grounded be attached to the frame, the other terminal being applied as before, the lamps will show whether the core of the armature or field magnet is in electrical contact with the windings.

Hot Bearings

Hot bearings in motors and generators usually result from one of the following causes:

A too tight belt.

The oil-rings not in place.

The oil inferior in quality or insufficient in quantity.

The bearing surface of the shaft marred and causing excessive friction.

Bad commutation will sometimes heat the bearing on the commutator end of the shaft. Whatever the cause, a hot bearing should receive immediate and careful attention.

An Unwise Power-plant Lay-out and Some of the Results Entailed

By H. R. Mason

Curious defects in installation, design and lay-out occasionally get by the electrical experts in charge of central-station construction, with the result that badly arranged apparatus are turned over to the operating force. Trouble and recrimination follow, and are only ended when costly and extensive changes have been made. A trying case of this nature is illustrated herewith.

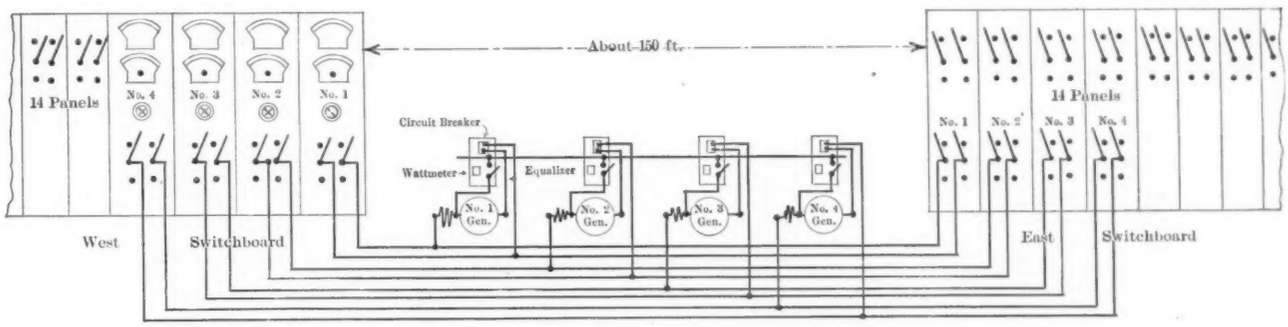


FIG. 1. SHOWING ORIGINAL LAY-OUT

Four 750-kilowatt 550-volt direct-current compound-wound generators connected to cross-compound horizontal Corliss engines were installed in a station designed to generate power for commercial purposes. In a plant of that class absolute reliability is the first considera tion, with strict economy in construction and operation details closely following To help insure the first, it was considered wisest to divide the feeders into two nearly equal groups, thereby establishing grounds at opposite ends of the building and guarding against the possibility of a short-circuit spreading to all of the feeders, a not infrequent happening. The lot upon which the building was erected was so narrow that it was impracticable to locate the switchboard lengthwise of the engine room, nor was the engine room wide enough at either end to permit the installation of a switchboard large enough to contain the generator panels and all of the feeder panels. It was decided, therefore, that there could be no objection to dividing the feeder board into two sections, thereby further reducing the chance

of a general short-circuit, locating a section at each end of the building, provided it would not require too much extra cable. It was so arranged, and Fig. 1 shows the lay-out.

The leads from each generator were carried the full length of the building, and connected on each board to the blades of double-throw switches, to supply current to high or low bus-bars, as desired. The ammeters, voltmeters and field rheostats were mounted upon the board at the west end of the engine room, and a single panel was placed close to each generator to receive a circuit-breaker, equalizer switch and recording wattmeter. Current from the bus-bars was delivered through all the feeders at different points on a set of mains, and the station was operated in parallel with a sub-station which was equipped with rotary converters of about 2000 kilowatts capacity, and a large storage battery, the center of which was "grounded" to form the neutral of a three-wire system. It was necessary to close the generator switches on both switchboards to accomplish the proper distribution of current.

Five times during three years accidents occurred to interrupt the service completely, and in about as many instances the feeders on one board or the other were cut out, causing improper distribution of load, which brought forth many complaints. Of course, every case of "trouble" was technically the fault of the operators, but no system of operation can be devised which will provide for every emergency, and signals are liable to be misunderstood or even improperly given. The routine employed in putting in a generator was as follows: The engineer, or chief operator, after getting the engine up to full speed, stationed the oiler at the engine to close the circuit-breaker and equalizer switch at a signal to be given when it was assured that the main switches of that generator were open on both switchboards. Another assistant was stationed at the east board to close the switches there, when signaled, while the operator went to the west board to cut in the unit. After adjusting the voltage he would close the switches on the west board, signal to the oiler to open the engine throttle wide, and to the other assistant to close the switches on the east board. A whistle was first used for signaling, but that proved less satisfactory than a pantomime similar to that used by railroad men.

The generators were very sensitive in the matter of load adjustment, and it frequently required several minutes to get them equalized. The cables and generator switches on either board were not large enough to carry the entire load more than a few minutes, therefore little time could be allowed to elapse after the switches on the west board were closed before those on the east board must be closed; and closing the switches on the east board naturally increased the load on the generator considerably. As close voltage regulation is almost a hobby in a commercial power plant, it will be seen that it was impossible for one man to properly attend to both boards.

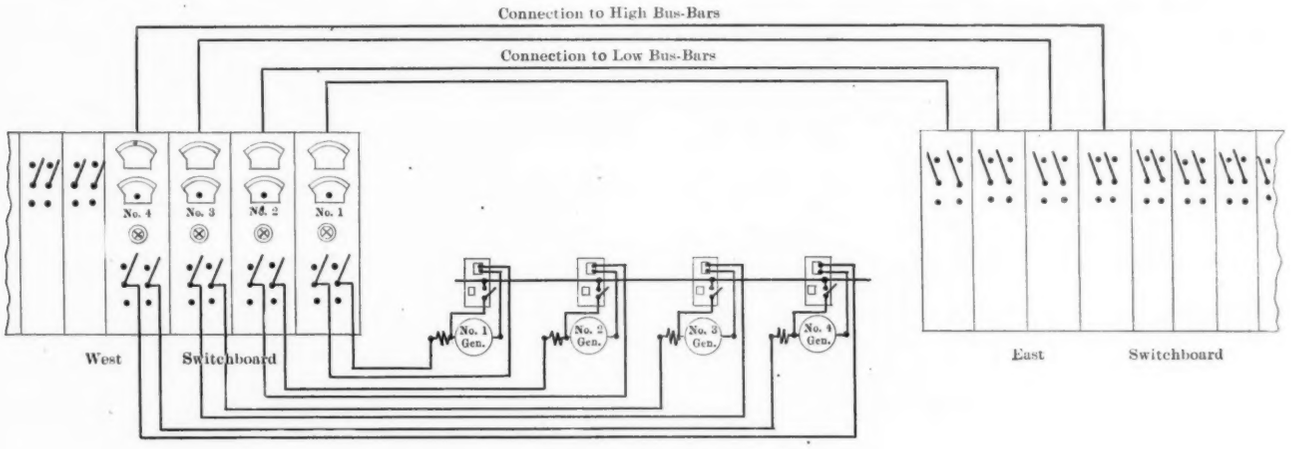


FIG. 2. SHOWING THE IMPROVED LAY-OUT

In cutting out a generator, the three men went to their respective places. The operator at the west board transferred the load from the machine to be cut out, until it carried but 300 or 400 amperes. Then he signaled to the assistant at the east board to open the switches there, and to the oiler to close the throttle and trip the circuit-breaker, while he opened the switches at the west board as the ammeter pointer approached zero.

The Accidents and their Causes

Following is a list of the accidents due to this method of installation, with the immediate causes, as far as could be determined:

1. A momentary short-circuit occurred on a feeder on the west board about 3 a.m., when only one unit was running. The operator was at the west board watching the voltage, when the circuit-breaker opened, and he immediately opened the generator switches on that board. He forgot to open the switches on the east board, however, and attempted to reset the circuit-breaker without doing so. When deprived of the current through the series field, the voltage of the generator fell below that of the sub-station, and closing the circuit-breaker caused the generator to become reversed. This created such a rush of current that the contacts of the circuit-breaker became fused together. The storage battery was thus short-circuited and the sub-station operator had to cut it out immediately to prevent it from being damaged.

2. Units Nos. 1 and 2 were in service. About 10 a.m. it was desired to shut down No. 2 for cleaning, so No. 4 was cut in and No. 2 cut out. The valve-gear of No. 4 was seen to be slightly out of adjustment, and it was quickly decided to cut No. 2 in again until the fault in No 4 could be corrected. No. 4 was therefore cut out and the signal given to the operator at the east board again to close the switches on No. 2. He misunderstood the signal, supposing it to mean that the switches on No. 4 were to be closed, so he closed them, when No. 4 generator had been cut out and its voltage was greatly reduced. The oiler had not reached the circuit-breaker on No. 4, and when the switches were closed the generator reversed and caused every circuit-breaker at both the main station and the sub-station to open, with the result that some of the plates in the storage battery became buckled in consequence of its rapid rate of discharge.

3. Units Nos. 1 and 3 were in service. No. 3 was to be shut down, owing to the load falling off late at night. A new man was at the east board, and he opened the wrong set of switches, cutting No. 1 off, and leaving No. 3 connected to the bus-bars, with the throttle closed He knew by the flash at the switch points that a mistake had been made, but did not locate it; nor could the other operator reach the circuit-breaker before the generator speed had fallen sufficiently to cause reversal again.

4. The fourth accident occurred in much the same manner as the preceding, except that it was due to inexcusable

carelessness. The operator at the east board was interested in something else when he should have been watching for the signal to open the switches.

5. About 4:30 p.m. one day in winter the peak load was rising fast, when one of the rotary converters at the sub-station flashed over and had to be taken out of service. Nos. 1 and 3 were running, and Nos. 2 and 4 were started together. No. 2 was equalized and cut in first. The operator at the east board misunderstood the signal and closed the switches on No. 4. An instant later the signal was given to close the circuit-breaker on No. 4, and when this was done the others opened. The storage battery and the converters were not knocked out immediately, and the circuit-breaker on No. 4 failed to break the arc when it was released by the attendant. The attendant was badly burned, and the arc lasted for fully a minute before the sub-station from which the current was being supplied was cut out. The circuit-breaker and the panel it was mounted upon were almost completely destroyed, and the commutator of No. 4 generator was badly burned. The temporary loss of the use of the unit was a hardship in itself.

How the System was Changed

After the last experience those in control decided to change the system to that shown in Fig. 2, which arrangement provides for the regulation of the cutting in or out of the generators from one point. For two years thereafter, while the same operating force was employed, there was not a single case of "trouble."

The changes in load during each 24 hours necessitated eight distinct operations in cutting machines in or out of service. In three years, therefore, this slightly complex process meant an aggregate of 10,000 operations performed by the three operators, with five serious mistakes, an average of one-twentieth of one per cent. Whether this is too high an average it might be interesting to debate, but by making it possible for one man to perform every step the record shows a tremendous decrease in liability to accident. Whereas in the original scheme almost any mistake would be serious, the second arrangement is nearly "fool-proof." With the voltmeter to guide him in cutting in and the ammeter in cutting out, there is practically no chance for the operator to make a mistake.

Tests of a 12-inch Doble Water-wheel

By A. L. Westcott

The needle valve of the Doble 12-inch water-wheel is shown in section in Fig. 1, and a cross-section of the bucket in Fig. 2. The needle of the valve is shown in the wide-open position by solid lines, and in the closed position by broken lines. The bucket angle α is that furnished by the manufacturers.

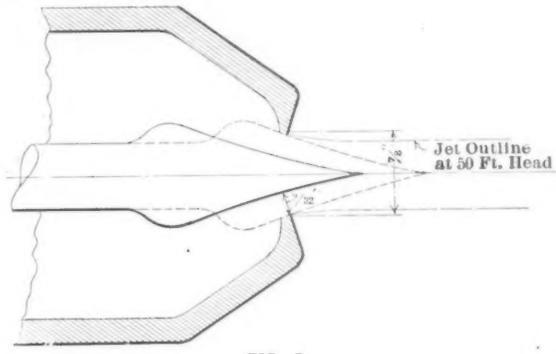


FIG. 1

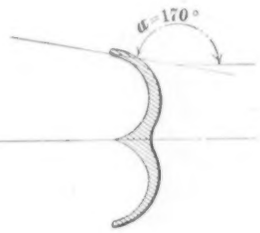


FIG. 2

The following tests were recently made by several sets of students at the University of Missouri. In each case, the procedure was as follows: With a constant head of water at the wheel, the needle valve was opened a small amount

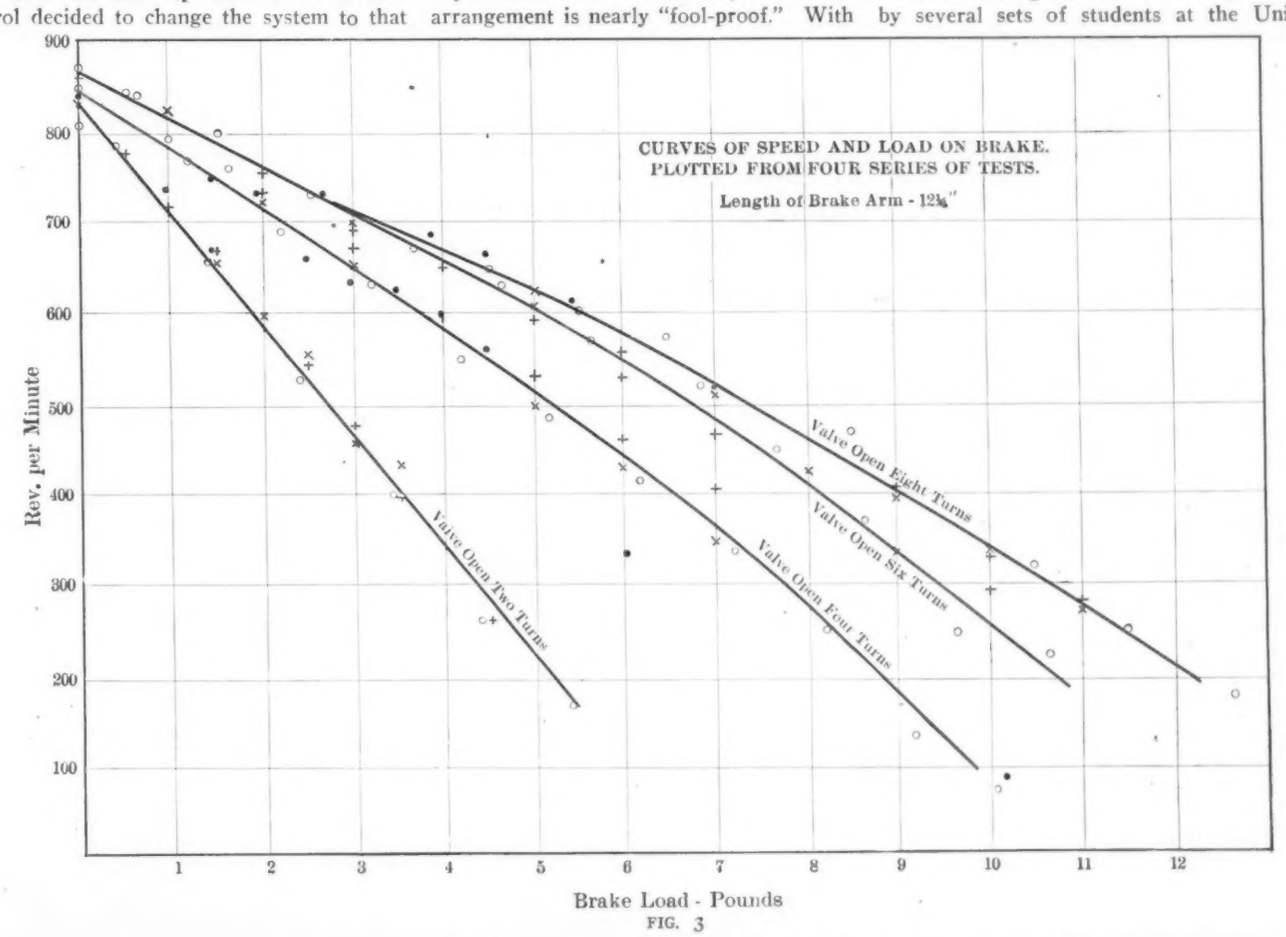


FIG. 3

—two turns of the valve spindle—and the loads were applied by means of a prony brake. The load on the brake was increased step by step and for each load the speed of the wheel was observed. Starting with no load, the speed was observed running free; and the final load was that with which the wheel was on the point of stopping. The amount of water used was determined by means of a weir.

Four sets of data were taken by each set of men with the valve spindle open two, four, six and eight turns, the last being the full open position.

In Fig. 3 all the observations of speeds and corresponding loads have been plotted as recorded by the different sets of observers, and then smooth curves drawn in which probably represent the true relationship between speed and brake load more truthfully than any one set of data From these curves were taken the brake loads corresponding to speeds ranging from 200 to 870 revolutions per minute (Tables 1, 2, 3 and 4), and these figures, together with the measurements of the quantity of water used, constituted the data for subsequent calculations.

Q = Cubic feet of water used per second,

w = Weight of water used per second $= 62.5 \times Q$,

h = Pressure head of water in pipe = 46 feet,

h' = Velocity head of water in pipe,

C = Velocity of jet, feet per second,

ϕ = Coefficient of jet velocity,

v = Velocity of buckets, feet per second,

α = Bucket angle = 170 deg (Fig. 2),

$B.H.P.$ = Brake horse-power,

E = Horse-power due to heads $= \dfrac{w(h+h')}{550}$,

E' = Horse-power of jet,

P = Theoretical horse-power given to buckets,

η = Efficiency, $\dfrac{B.H.P.}{E}$,

η' = Efficiency, $\dfrac{B.H.P.}{E'}$,

η'' = Efficiency, $\dfrac{B.H.P.}{P}$.

It was found that, for the data under consideration, the velocity head h' was negligible.

The coefficient of velocity of the jet ϕ was taken at 0.98, and, therefore, velocity =

$$C = 0.98\sqrt{2gh}.$$

The pressure head for the entire series was 46 feet, and therefore,

$$C = 0.98 \times 8.02 \times \sqrt{46}$$

$$= 53.3 \text{ feet per second.}$$

The theoretical energy of the water is

$$E = \frac{wh}{550}.$$

The energy of the jet:

$$E' = \frac{w\,C^2}{2g \times 550}$$

$$= 0.98^2 \frac{wh}{550} = 0.96 \frac{wh}{550} 0.96\,E.$$

The theoretical power delivered to the buckets by a jet of velocity C is found from the formula:

$$P = \frac{w(C-v)(1-\cos.\alpha)v}{g \times 550}.$$

The maximum value of P (see Church's "Hydraulic Motors," page 67, formula 7) may be found by making $v = \frac{1}{2}C$. For $\alpha = 170$ degrees, we have $1 - \cos.\alpha = 1.985$, and

$$P_{max.} = \frac{w\,C^2}{4g \times 550} \times 1.985$$

$$= 0.992 \frac{w\,C^2}{2g \times 550} = 0.992\,E'.$$

The efficiency $\eta = \dfrac{B.H.P}{E}$ gives us the usual ratio of output to input, that

TABLE 1. NEEDLE VALVE OPEN TWO TURNS.

1	2	3	4	5	6	7	8	9
	Speed R.P.M.	v Ft. per Sec.	Brake Load.	$B.H.P.$	P	η	η'	η''
$E = 0.337$	200	10.47	5.21	0.202	0.202	60.0	62.5	100.0
$E' = 0.323$	300	15.71	4.32	0.251	0.268	74.5	77.5	94.0
Head $h = 46$ ft.	400	20.95	3.50	0.271	0.307	80.5	84.0	88.0
Quantity of water used per second = 4.04 lb.	500	26.18	2.70	0.261	0.322	77.5	81.0	81.0
	600	31.42	1.85	0.215	0.312	64.0	66.5	69.0
	700	36.65	1.05	0.142	0.277	42.0	44.0	51.0
	800	41.90	0.25	0.038	0.217	11.5	11.8	17.5
	825	43.20	0.0	0.0	0.199	0.0	0.0	0.0

TABLE 2. NEEDLE VALVE OPEN FOUR TURNS.

1	2	3	4	5	6	7	8
	Speed R.P.M.	Brake Load Pounds.	$B.H.P.$	P	η	η'	η''
$E = 0.602$	200	8.85	0.343	0.363	57.0	59.5	94.5
$E' = 0.577$	300	7.72	0.449	0.478	74.5	78.0	94.0
Head $h = 46$ ft.	400	6.58	0.510	0.549	84.7	88.5	93.0
Quantity of water used per second = 7.2 lb.	500	5.20	0.504	0.575	83.6	87.5	87.5
	600	3.70	0.430	0.557	71.5	74.5	77.5
	700	2.22	0.301	0.495	50.0	52.0	61.0
	800	0.75	0.116	0.388	19 2	20.0	30.0
	845	0.0	0.0	0.326	0.0	0.0	0.0

TABLE 3. NEEDLE VALVE OPEN SIX TURNS.

1	2	3	4	5	6	7	8
	Speed R.P.M.	Brake Load Pounds.	$B.H.P.$	P	η	η'	η''
$E = 0.795$	200	10.75	0.417	0.479	52.5	54.5	87.0
$E' = 0.763$	300	9.45	0.550	0.632	69.0	72.0	87.0
Quantity of water used per second = 9.5 lb.	400	8.15	0.633	0.725	79.5	83.0	87.5
	500	6.80	0.660	0.760	83.0	86.5	87.0
	600	5.03	0.585	0.735	73 5	76.5	79.5
	700	3.10	0.421	0.654	53.0	55.0	64.5
	800	1.30	0.202	0.513	25.0	26.5	39.5
	870	0.0	0.0	0.382	0.0	0.0	0.0

TABLE 4. NEEDLE VALVE OPEN EIGHT TURNS.

1	2	3	4	5	6	7	8
	Speed R.P.M.	Brake Load Pounds.	$B.H.P.$	P	η	η'	η''
$E = 0.885$	200	12.20	0.474	0.532	53.5	56.0	89.0
$E' = 0.850$	300	10.62	0.619	0.704	70.0	73.0	88.0
Quantity of water used per second = 10.56 lb.	400	9.00	0.698	0.806	79.0	82.0	87.0
	500	7.40	0.717	0.845	81.0	84.5	85.0
	600	5.50	0.640	0.818	72.5	75.5	78.5
	700	3.20	0.435	0.726	49.0	51.0	60.0
	800	1.30	0.202	0.570	23.0	24.0	35.0
	870	0.0	0.0	0.425	0.0	0.0	0.0

is, the ratio of the power realized at the brake wheel to that delivered to the needle-valve inlet, and takes into account all losses, consisting of valve friction, imperfect bucket action, incorrect bucket speed and journal friction. Then

$$\eta' = \frac{B.H.P.}{E'}$$

gives the ratio of brake power to that of the jet, and takes account of losses in the wheel only. In

$$\eta'' = \frac{B.H.P.}{P}$$

the loss due to bucket velocity, being other than the most advantageous, that is, equal to one-half of the jet velocity, is eliminated, and we have simply the ratio of brake power to that which is theoretically possible under the existing conditions of jet and bucket velocities. This, then, is a measure of the proportion of internal losses due to journal friction and to imperfect bucket action.

Figs. 4, 5, 6 and 7 show these various relationships, the curves being plotted from the computed data of Tables 1, 2, 3 and 4. It will be noticed that the brake-horse-power curve passes through its maximum value at a somewhat lower speed than that of the curve P. Also, it is interesting to note that the curves of η'' increase steadily with the decreasing speed.

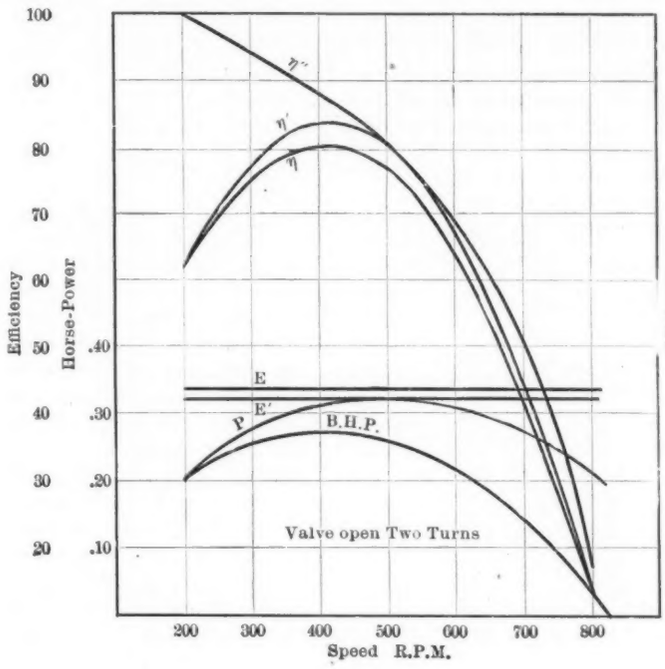


FIG. 4

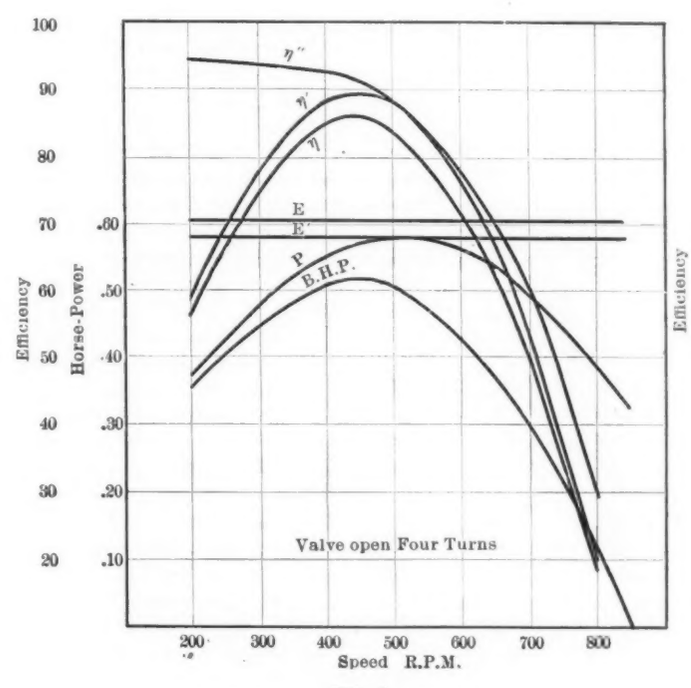


FIG. 5

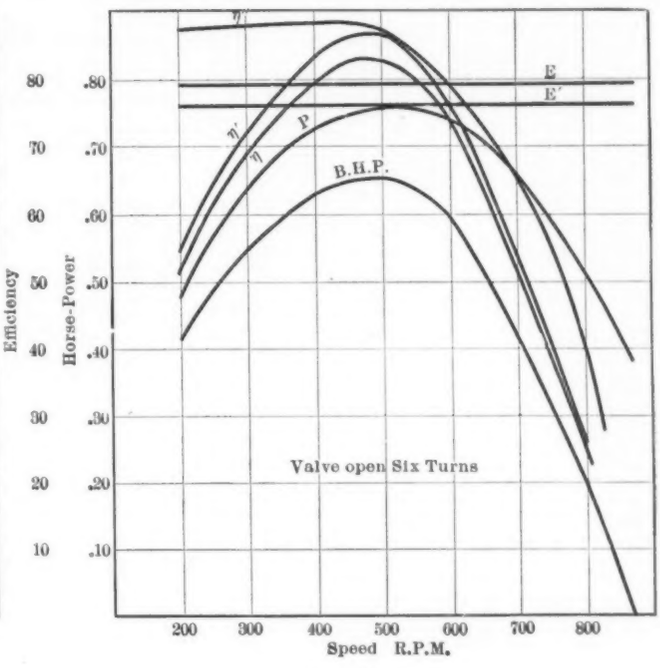


FIG. 6

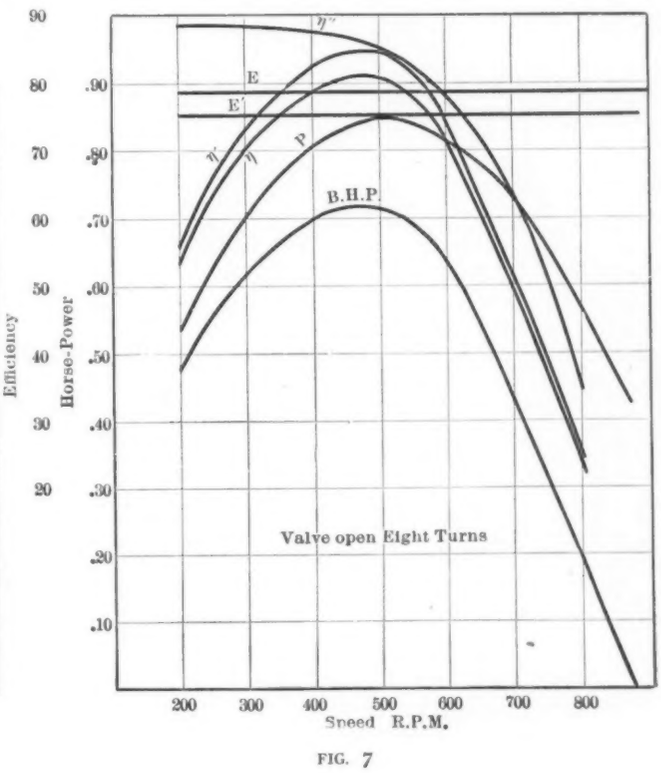


FIG. 7

Method of Testing Direct-current Dynamos

How to Measure Insulation Resistance, Locate Connections and Determine the Rating and Characteristics of a Dynamo

BY E. S. LINCOLN

Insulation Resistance

There are several methods of measuring the insulation resistance of a direct-current dynamo, but the most convenient and practical method is known as "the voltmeter test for insulation resistance." To obtain good results with the voltmeter test a voltage of 500 or over should be available, or at least a voltage equal to that at which the machine is rated. The resistance of the voltmeter must be known, of course, and this can be found on the inside of the case, if a Weston voltmeter is used. For a 150-volt instrument of this type the resistance is about 15,000 ohms; that of a 600-volt instrument is between 60,000 and 80,000 ohms.

The test is very simple. The voltmeter is connected across the source of current and the deflection noted. The instrument is then connected in series with the frame of the dynamo (be sure this connection is perfect) and the circuit completed by connecting the other side of the line with a terminal of the machine. The connections are shown in Fig. 1, where V is the voltmeter and S a single-pole double-throw knife-switch. By throwing the blade up, the line voltage can be obtained; for the second reading, it is thrown down. The frame of the machine is represented at A, while B indicates the free terminal of the winding.

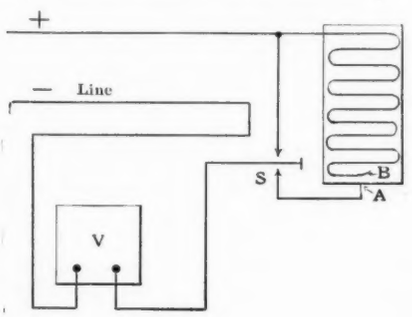


FIG. 1

The insulation resistance is calculated from the formula

$$X = R \times \frac{D - 1}{d},$$

in which X = the insulation resistance, R = the resistance of the voltmeter, D = the first, or highest, deflection of the voltmeter, and d = the second, or low, deflection. Not more than one-millionth of the rated current of a machine should pass through the insulation at its normal voltage. To illustrate the use of the formula, assume that the 150-volt instrument indicated 110 volts when connected to the line and a deflection of 1.5 volts on the second reading; then,

$$X = 15{,}000 \times \frac{110 - 1}{1.5} = 1{,}090{,}000$$

ohms of insulation resistance. To obtain the insulation resistance under normal running conditions, it should be done when the machine is thoroughly heated.

Where a number of dynamos are to be tested for insulation resistance, marks indicating varying amounts of resistance may be permanently located on the voltmeter scale, the following formula being employed to determine them:

$$d = \frac{110\,R}{X + R},$$

in which d = the number of volts, opposite which should be placed the corresponding graduation to form the new scale; R = the resistance of the voltmeter, X = the insulation resistance, and 110 = the voltage used in *all* the measurements. (In this case 110 is used for illustration, only, and can be replaced by any other value, preferably a higher one.) The insulation resistance should be indicated in megohms, ½ megohm, ¼ megohm, etc., so as to avoid long numbers on the scale. In using such an instrument, calibrated in this way, the same voltage must be used when testing as when the graduations were made.

The insulation resistance of the armature and fields may, of course, be tested separately, first disconnecting them electrically.

Dynamo Testing

The first step to be taken in testing a dynamo is to determine its rating, and the second step is to locate all its connections. In Fig. 2 are shown the connections of both shunt- and compound-wound types. The shunt windings comprise numerous turns of comparatively small wire, while the series winding consists of a few turns of large wire in small machines, heavy bar copper being used in large machines instead of wire coils. By locating the windings and their connections with the brushes, it is an easy matter to determine the kind of dynamo. In Fig. 2 the position of the rheostat in the shunt-wound machine is shown to illustrate why three wires are usually run to a machine instead of two or four. A series-wound machine has no shunt winding and is connected in the same manner as the compound-wound dynamo in Fig. 2, omitting the shunt field winding.

It sometimes happens that the nameplate on a dynamo does not indicate its rating, or perhaps the nameplate has been removed and is lost. In such case, one can get an idea as to the output by examining the windings. If it is a compound-wound machine and its series winding is composed of very large wire, with few turns, while its brush and commutator are large, compared to the size of the dynamo, it will probably deliver a low voltage and high amperage. Conversely, in most cases a fine-wire winding, with many turns, in the shunt field indicates a high voltage. A high-speed machine will have a small armature as compared with its field-magnet, which will have few poles. When the field-magnet and armature are of about the same proportions, the machine will probably run at medium speed. A low-speed machine will have a large armature in comparison with its field-magnet, which will have a number of poles. These deductions apply to dynamos of equivalent capacity. Judgment of the output and speed of dynamos formed in the manner outlined is, of course, only approximate. Any speed up to 600 revolutions per minute might be considered low for small machines, from 600 to 1000 revolutions per minute would be medium speed, and above 1000 revolutions per minute high speed. For large machines the figures would be reduced nearly 50 per cent. Accuracy in estimating will depend chiefly upon experience in dynamo design and operation, and the ability to reason.

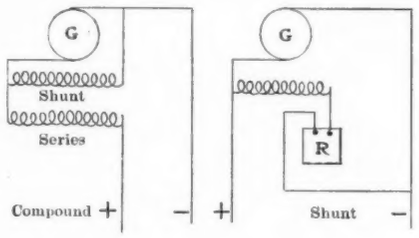


FIG. 2

Incandescent lamps will be found convenient for determining voltage. By starting with a number of lamps in series and gradually cutting them out, a good idea of the voltage of a dynamo can be

obtained. For instance, ten 100-volt lamps in series would require 1000 volts to burn each lamp at its rated candle-power. By short-circuiting one lamp at

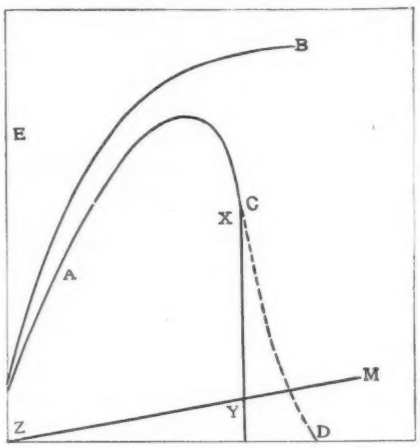


FIG. 3

a time the approximate voltage of the line can be regulated, if each lamp is burning at or near its rated candle-power.

Characteristic Curves

There are three characteristic curves for every dynamo—the internal, the external and the total. The internal characteristic curve shows the relation between the current and electromotive force in the machine circuit, its armature, field winding, etc. The external curve indicates the relation between the amperes and volts delivered to the external circuit supplied by the dynamo, such as the amperes and volts delivered to a power or lighting circuit. The third, or "total" curve, takes into consideration the total current and voltage, i.e., both the internal and external. The shape of the characteristic curve depends upon the method of connection between the armature and field winding of the generator. These curves are plotted on cross-section paper and the usual method is to plot the volts on the vertical lines, as ordinates, and the amperes on the horizontal lines, as abscissas. In many cases these curves can be figured out mathematically, but the most accurate method is to test the finished machine.

Referring to Fig. 3, the curve *A* represents the external characteristic of an arc-light series generator. It will be noticed that the curve does not start at the origin. This is due to the fact that a small amount of magnetism remains in the field-magnet. This is termed "residual magnetism." Without this magnetism it would be impossible for the machine to start up under its own excitation. The curve runs up very steeply until the iron in the field-magnet approaches the point of saturation. The load is increased until the machine is finally short-circuited. The curve drops in a straight line, due to a governor which changes the position of the brushes. It is upon this portion of the curve, from *X* to *Y*, that the load, which usually consists of arc lamps burned in series, is carried. The dotted line *C-D* represents the characteristic that would be obtained if the position of the brushes were unchanged. It will be seen that the machine delivers a constant current, with its voltage varying to suit the resistance of an external circuit. The curve *B* is the "total" characteristic curve, and is obtained by multiplying the current by the internal resistance of the machine and adding the result to the voltage of the external characteristic. These values can be taken from the loss line described later.

Great care must be taken, when obtaining these curves from a series machine, that the circuit is never broken, as the voltage will rise to a very high value, due to the self-induction of the armature and field-magnet. The connections for a series machine are shown in Fig. 4 where *G* is

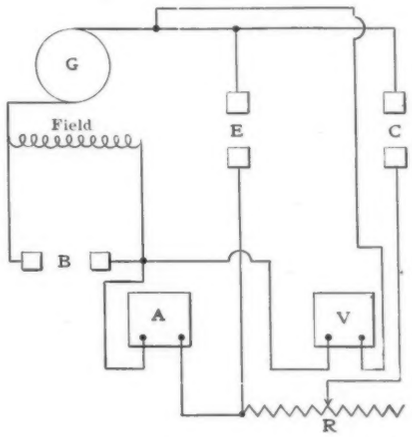


FIG. 4

the generator, *A* is the ammeter and *V* is the voltmeter. A variable resistance is represented at *R* and should be so arranged that the circuit will never be broken. The switch *B* is used to short-circuit the field winding in case it is necessary to adjust connections or make changes. The ammeter and voltmeter readings should be simultaneous. Before starting, see that the generator and governor are in perfect condition and that the machine is properly connected to the circuit. The speed throughout the run must be kept constant. The first reading is taken with the switch *C* "off," to get the voltage at which the curve is to start. The switch *C* is then closed and the variable resistance *R* is gradually cut out, readings being taken at various points in the resistance to obtain a smooth curve. When the last point is reached the switch *E* is closed to short-circuit the machine, and this will give the last point on the curve. In this last reading the voltage will be zero, but the current will vary little from the other reading, if the governor is in proper working order.

In starting such a test it must be seen that the current is passing through the field winding in the proper direction for the machine to "build up." If this is not the case, simply reverse the terminals of the winding.

The line *M Z*, Fig. 3, is the resistance line of the dynamo. This line is obtained by multiplying the known internal resistance of the generator by the different currents, given as abscissas. Only one value is necessary, however, to determine the loss line, and an illustration will be of assistance. Suppose the resistance of the generator, measured at its terminals, is found to be 3 ohms. (This measurement should be made after the run when the machine is at working temperature.) Multiply the resistance of 3 ohms by, say, 10 amperes, which gives 30 volts. Then find a point on the plotting paper which corresponds with 10 amperes and 30 volts. From this point draw a straight line to the origin, and this will be the loss line. The resistance of the machine is obtained by the drop method already described. It may be necessary to block the armature to prevent it from running as a motor in the reverse direction. Each reading of the instruments must be carefully noted, and it is important that readings should not be repeated, as the same values cannot be obtained on account of the hysteresis of the field-magnet.

The internal characteristic curve of a series dynamo is obtained by plotting the voltage of the armature and the current in the field winding, but it is necessary, of course, to excite the field-magnet by means of an adjustable current taken from some separate source.

Shunt-wound Dynamo Characteristics

The characteristic curves of a shunt-

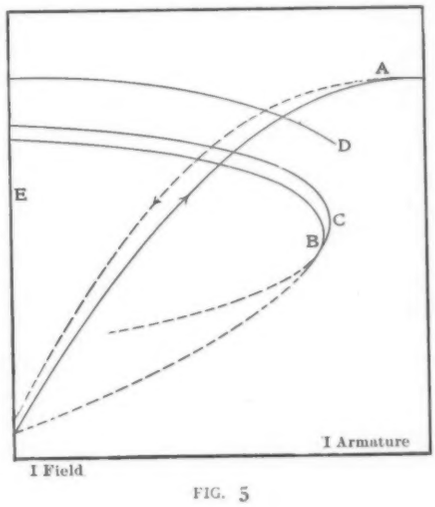


FIG. 5

wound dynamo are shown in Fig. 5. The curve *A* is the internal characteristic or magnetization curve of the generator. It is obtained by plotting the current in the

field winding as abscissa and the volts at the terminals of the machine as ordinates, the machine running free. This curve is similar to the characteristic curve of a series machine. It bends over as the current increases, due to the field-magnet nearing the point of saturation. If increased, it would run in a practically straight line. The dotted line back of the curve *A* represents the values when the current is decreased, using the highest readings as a starting point. This peculiar condition is due to the residual magnetism of the iron in the field-magnet. The curve *B* represents the external characteristic and is obtained by plotting the current delivered to the external circuit as abscissa and the voltage at the brushes as ordinates. This curve tends to bend backward as the load is increased. The voltage drops, due to the resistance of the armature, or more properly the *IR* or amperes × resistance drop of the armature. This decrease in voltage allows less current to flow in the field winding and in turn still further decreases the

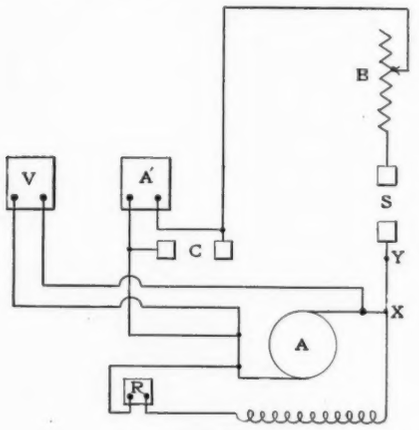


FIG. 6

voltage of the dynamo. If the voltage at the field-winding terminals were kept constant the curve would not bend backward, but would take the form of the curve *D*, which represents the armature characteristic. The drop in this curve is due to the resistance of the armature only. From the foregoing it can be seen that the peculiar bend in the external curve is due to the drop in voltage at the field-winding terminals. In large dynamos the values of the bending portion of the curve cannot be obtained, as the large amount of current flowing in the armature would be liable to injure it.

The "total" characteristic curve is indicated at *C* and is obtained by adding the current in the field winding to the value of the current in the external circuit. In order to obtain the voltage of the total characteristic, the resistance of the armature must be known and this multiplied by the different values of current will give the total voltage.

The internal characteristic or magnetization curve is obtained by running the machine without load and plotting the voltage at the brushes, and the current in the field winding. The field-regulating rheostat and a low-reading ammeter are connected in series with the fields. The speed of the machine must be kept constant. Starting with the field circuit broken, the origin of the curve is obtained. The voltage at this point is due to residual magnetism, as previously stated. Gradually cut the resistance out and take readings at enough points to get a smooth curve. It is important that this circuit should not be broken unless all the resistance is in the circuit. Never repeat readings, but if a mistake is made start the whole curve over again, after waiting a few minutes for the magnetism to return to its former condition.

The connections for the external characteristic curve are shown in Fig. 6, where *A* indicates the armature of the generator. The current passes from the brushes to a switch *S*, and then enters the variable resistance *B*. The form of resistance used, whether lamps, wire or barrel, will depend upon the size of the dynamo. The ammeter and voltmeter are represented at *A'* and *V*, respectively. The field rheostat is shown at *R*, connected in the field circuit, which should remain unchanged after the voltage has been equalized with that at which the machine is rated. The generator is first brought up to its rated speed and its voltage properly adjusted. Before starting be sure that the machine is in perfect order and properly oiled. When everything is ready close the switch *S*, making certain that all the resistance is "in" at the variable rheostat *B*. Open the short-circuiting switch *C* and determine whether the ammeter is properly connected in the circuit or not. If the wrong polarity exists cut the instrument out and reverse its leads. With the switch *C* open, gradually cut out the resistance *B* until the machine is overloaded about 50 per cent., being careful that it does not get too hot. When the highest reading has been taken, unload the machine and break the circuit. The speed throughout the test should be kept as constant as possible, readings being taken at frequent intervals and recorded.

Compound-wound Dynamo Characteristics

Referring again to Fig. 5, once more note the drop in voltage as the load increases. If the field current should be increased in proportion as the load increases, a straight line would be the result. The object of the series winding is to furnish this increase in the magnetizing power and raise the voltage of the armature. Its effect is like that of an automatic rheostat which increases or decreases the field strength according to the load on the generator. In most cases, however, it is desired to increase the voltage of the generator in order to compensate also for line losses. The dynamo is then said to be over-compounded, the compensation necessary varying by from 2 to 15 per cent., according to the class of service. In this case the curve would rise as the load increases; in the case of a 500-volt machine over-compounded to compensate for a 10 per cent. loss, for example, the voltage would be 550 volts at full load. The percentage of compensation furnished can be varied by shunting the series winding, as shown at *S*, Fig. 7. The current will then divide, part flowing through the series field winding and the remainder through the shunt which usually consists of german-silver ribbon. This method of regulating the compounding is useless when machines are to be operated in parallel, as will be explained later on, but works satisfactorily with a single machine.

The curves for these machines would be obtained in the same way as for the

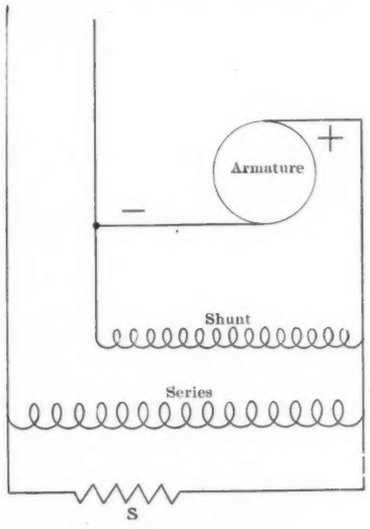


FIG. 7

shunt-wound machine in Fig. 6. The only difference would be that the series field coils would be in series with the line at the points *X* and *Y*, *X* representing the brush terminal, and *Y* the terminal of the dynamo. The voltmeter lead would then be connected at the new terminal of the machine, or at *Y*. The dynamo would be of the "short-shunt" type with the connection as shown, and of the "long-shunt" type if the shunt field winding were connected at the point *Y*, thereby causing the shunt field current to pass through the series winding. In practice it makes very little difference which method of connecting the shunt winding is used, as both give practically similar results.

According to a recent utterance of Hon. Charles A. Parsons, the turbine inventor, six years ago there were 75,000 horse-power of turbines on land and 25,000 on sea. At present there are more than two million horse-power on land and 800,000 horse-power at work or building for use at sea.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

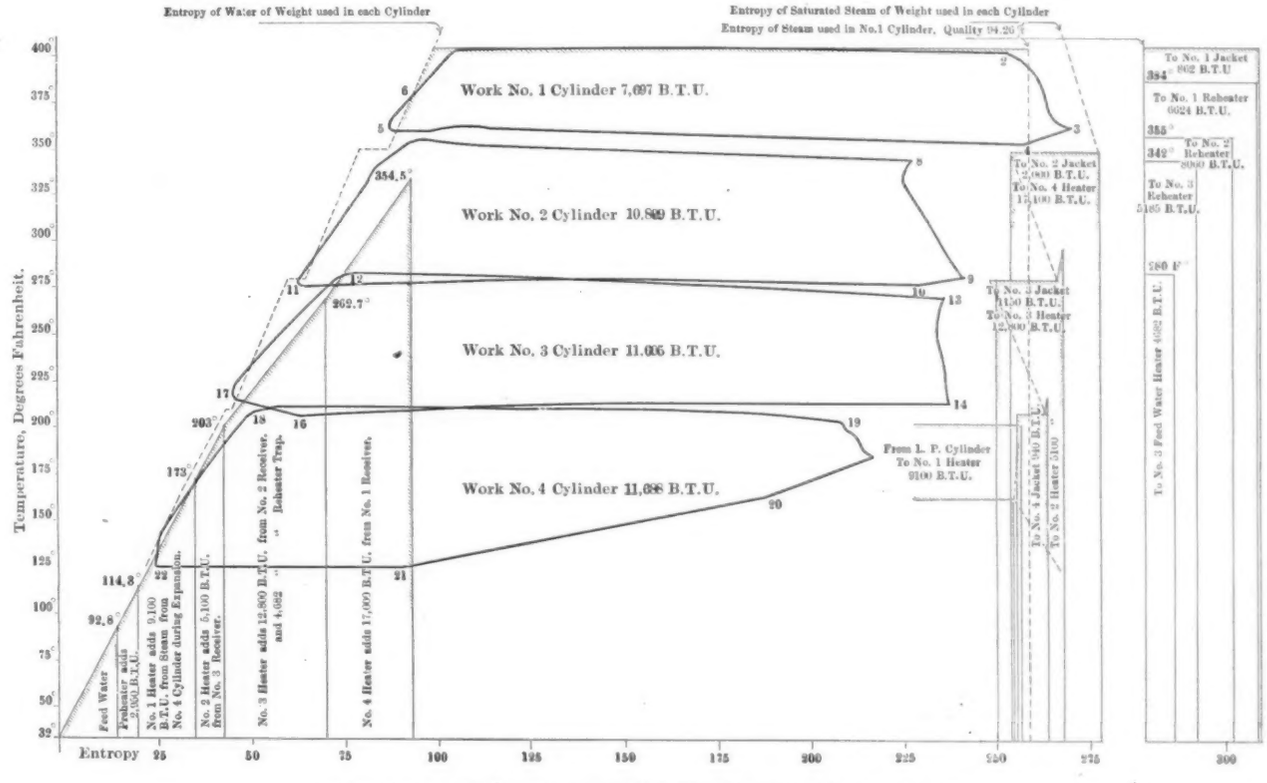
WE PAY FOR USEFUL IDEAS

"Compounding Piston Engines with Turbines"

In your translation of Professor Rateau's paper, in the October number, on combining reciprocating and turbine engines, reference is made to the performance of a Nordberg engine. Professor Rateau desires to illustrate the superiority of the turbine over the reciprocating engine in the range of low pressures, and the losses due to incomplete expansion are illustrated by the entropy diagram of the Nordberg engine. In this diagram (Fig. 3 reproduced) the line from 19 to 21 includes much less area than it would have done had the form been that realized in the second intermediate cylinder from 13 to 14. But the computations of Professor Rateau referring to this diagram are so far from correct that they should not go unchallenged. The dry-steam consumption is correctly reported as 11.23 pounds per indicated horse-power, and the condenser pressure as 1.25 pounds. If the steam had all been thrown away at the condenser temperature as usual then this 11.23 pounds would measure the cost of a horse-power in steam consumption. The theoretical limit of steam consumption under these conditions is eight pounds of steam per indicated horse-power. The apparent efficiency then might seem to be 8/11.2 or 71 per cent. instead of the 60 per cent. stated.

But this engine did not discharge all of its heat at this lower temperature. It was the peculiar feature of this engine that some 30 per cent. of the steam fed to the high-pressure cylinder was returned to the feed-water without ever coming to the condenser. This side-tracked steam, after having done some work, was put into the feed-water with all of its latent heat and did not contribute any heat to be wasted in the circulating water. Each of the succeeding four cylinders received a less weight of steam to work with, the abstracted amount being all returned to the feed-water. Instead of sending feed-water back to the boiler at a temperature of 109.6 degrees from the condenser this engine returned feed-water at a temperature of 334.5 degrees. Surely the engine should have credit for the heat thus returned. An exact parallel would be to run a boiler test and make no allowance for the low temperature of cold feed-water in figuring the evaporative performance of the boiler. This engine returned so much heat to the feed-water that the equivalent steam consumption instead of being 11.23 pounds was practically 9 pounds per indicated horse-power on the basis that Professor Rateau has chosen for comparison. The equivalent steam consumption of 9 pounds therefore compared with the theoretical limit shows the remarkable efficiency of over 88 per cent. This 9 pounds is computed as follows: The heat content of the wet steam sent to the engine was 1157.4 B.t.u. per pound and there was returned to the boiler 305.1 B.t.u. per pound. There should be charge to the engine, therefore, the difference of 852.3 B.t.u.

Had the feed-water gone back to the boiler at the condenser temperature of 109.6 there must be added 1127 B.t.u. per pound to produce dry steam. The engine actually consumed by measurement 10,157 B.t.u. per indicated horse-power and 10,157 ÷ 1127 = 9 pounds per horse-


Entropy of Water of Weight used in each Cylinder
Entropy of Saturated Steam of Weight used in each Cylinder
Entropy of Steam used in No.1 Cylinder, Quality 94.2%
Temperature, Degrees Fahrenheit.
Entropy
Work No. 1 Cylinder 7,097 B.T.U.
Work No. 2 Cylinder 10,869 B.T.U.
Work No. 3 Cylinder 11,036 B.T.U.
Work No. 4 Cylinder 11,688 B.T.U.
Feed Water
Feedwater adds 2,500 B.T.U.
No. 1 Heater adds 9,100 B.T.U. from Steam from No. 4 Cylinder during Expansion.
No. 2 Heater adds 5,100 B.T.U. from No. 3 Receiver.
No. 3 Heater adds 12,800 B.T.U. from No. 2 Receiver, and 4,062 " Reheater Trap.
No. 4 Heater adds 17,000 B.T.U. from No. 1 Receiver.
To No. 1 Jacket 802 B.T.U.
To No. 1 Reheater 6024 B.T.U.
To No. 2 Reheater 8060 B.T.U.
To No. 3 Reheater 5,185 B.T.U.
To No. 2 Jacket 2,080 B.T.U.
To No. 4 Heater 12,100 B.T.U.
To No. 3 Jacket 1150 B.T.U.
To No. 3 Heater 12,800 B.T.U.
From L. P. Cylinder To No. 1 Heater 9100 B.T.U.
To No. 4 Jacket 940 B.T.U.
To No. 2 Heater 5100
To No. 3 Feed Water Heater 4062 B.T.U.
354.5°
262.7°
203°
173°
114.8°
92.8°

PROFESSOR RATEAU'S FIG. 3 REPRODUCED FROM THE OCTOBER NUMBER

power per hour. The error of Professor Rateau, in stating the efficiency as 60 per cent. instead of 88 per cent., comes from making computations on steam consumption instead of on heat consumption and well illustrates the serious objection to the steam consumption as a measure of the performance of an engine. Where engines work between very similar limits the errors due to comparing steam consumption escape notice, but where very dissimilar conditions prevail the method leads to confusion and error. Where two engines use the heat in a different cycle it is all the more necessary to discard steam consumption and base figures on the heat consumption. The true basis of computing the efficiency of the Nordberg engine is not to compare it to the theoretical Rankine cycle but to the Carnot cycle. Such a comparison shows it to have an efficiency of 73.7 per cent., although if the engine is to be compared with engines using the usual Rankine cycle the 88 per cent. is the figure for comparison. The usual engine discharges its heat at the condenser temperature but the Carnot cycle demands that the engine send back the condensed water at the boiler temperature and this is the attempt of the Nordberg engine. It is this better manner of using heat that makes possible the duty of nearly 195,000,000 foot-pounds of work for 1,000,000 heat units used.

The computations concerning the low-pressure cylinder are also quite incorrect. It has apparently not been taken into account that the low-pressure cylinder receives only 70 per cent. of the steam fed to the high-pressure cylinder. To accentuate the loss by incomplete expansion in the low-pressure cylinder Professor Rateau figures that this low-pressure cylinder realized only 45 per cent. of what was possible. Without computation the eye can see from the entropy diagram published that the work area of No. 4 cylinder is more than 45 per cent. of the available area between the "entropy of water" and the "entropy of steam" lines to the left and right, respectively, of the low-pressure temperature range. The theoretical possibility of this cylinder working between the limits of 13.3 pounds and 1.25 pounds would be to return in work 12.3 per cent. of the heat sent to it, or 143.6 B.t.u. per pound.

There was fed to this cylinder 145.5 pounds of steam per minute, but only 136 pounds reached the condenser, the balance going to heaters. The possible work was therefore $136 \times 143.6 = 19{,}529$ B.t.u., and there was actually realized work equal to 11,688 B.t.u., showing an efficiency of 60 per cent. instead of the 45 per cent. quoted.

If we charge the full 145.5 pounds of steam to this cylinder the efficiency is 56 per cent. The efficiency of the low-pressure cylinder is therefore between 56 and 60 per cent. while the efficiency of the whole engine figured on the same basis is 88 per cent. The difference, therefore, between the performance of the low-pressure cylinder and the others is sufficiently startling without exaggeration and makes the point that Professor Rateau desires to make.

A turbine can certainly utilize these low pressures to better advantage than a reciprocating engine of commercial proportions and apparently the most valid objection to the combination is not one of economy but of complication in having in one unit the two dissimilar constructions. With some people this would be a serious objection, but there are an increasing number who are considering the necessity of becoming acquainted with the unfamiliar types of heat engines which are forcing themselves upon our attention.

O. P. Hood.

Houghton, Mich.

"Sub-station Troubles"

The article under the above title, on page 659 of the October number, was very interesting. What appealed to me particularly was the author's description of the method of starting up rotary converters after a shut-down by tying through to the generating station, starting up the generators and bringing the converters up to speed with them. One of the large central stations recently gave this method a thorough trial and found it to be a good emergency measure in case the storage batteries were discharged, and so rendered unavailable for starting up the converters from the direct-current side.

I would like to ask the author, however, if in his experience the converters stalled and refused to start with the generators. I have it on good authority that when this method was tried on an extensive city railway system the converter armature rocked so violently as to shake the building, and in another case the armature refused to turn and was soon smoking. In both cases I believe the converters were 6-phase machines.

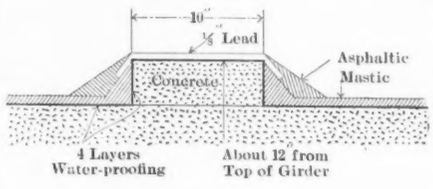


FIG. 1

In connection with Mr. Wohlgemuth's description for the care of a converter commutator it may be of interest to note the method adopted by the large central station already mentioned for lubricating the commutator and preventing excessive wear by the brushes. One brush was removed from each brush-holder, the position of each brush being staggered around the commutator. These brushes were then soaked in lubricating oil and replaced. The commutator was thus lubricated for its entire width by the brushes arranged as a helix around it.

One of the smaller sub-station difficulties which the author does not mention is to provide a floor covering in the battery room which shall be acid proof and prevent any acid from seeping through and attacking leads, apparatus and the like. This, of course, is in case the battery room is on an upper floor. If it be in the basement, the matter of preventing leakage is not so important.

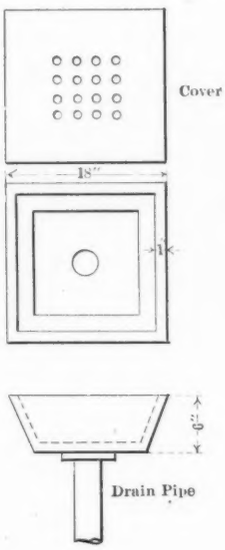


FIG. 2

In the former case a floor constructed as shown in Fig. 1 herewith has done excellent service. The filling over the floor girders is about 12 inches thick, extending to the top of the concrete piers on which the feet of the battery tanks stand. The piers are about four or five inches high, ten inches wide, and as long as the width of the tank.

Four layers of waterproof covering are placed on the concrete up to the top of the piers. The "asphaltic mastic" is placed over the waterproofing, as shown in the sketch. This closely resembles the asphalt used in street paving, but has the advantage that it does not require heavy rolling. Sheet lead, ⅛ inch thick, is then placed on top of the pier and bent over the edges, after which more asphaltic mastic is placed around the sides and ends of the pier to act as a binder for the lead.

The floor is so graded as to drain to one corner where a "lime box" is located, the cover being flush with the floor. This lime box is made of alberene stone, as shown in Fig. 2. The cover has a number of holes drilled in it and to the bottom is fixed a lead drain-pipe, the end being flanged out and held against the bottom of the box by means of a stone collar fastened by screws.

Another type of floor covering is what

is called a "granolithic" finish. To render this additionally acid proof it has in some cases been coated with paraffin. Where this construction is used, however, it will be necessary to construct wooden runways between the rows of cells, as without them the paraffin would be scraped off by walking on it. It will also be necessary, whatever type of construction is used, to coat the walls with an acid-proof finish to at least six inches above the tops of the cells. The spray from the batteries near the walls is often active enough to wet the latter considerably. In connection with this, it may be said that the granolithic finish has a slight advantage over the asphaltic finish, as the latter, in some cases, has refused to adhere to the plastered wall.

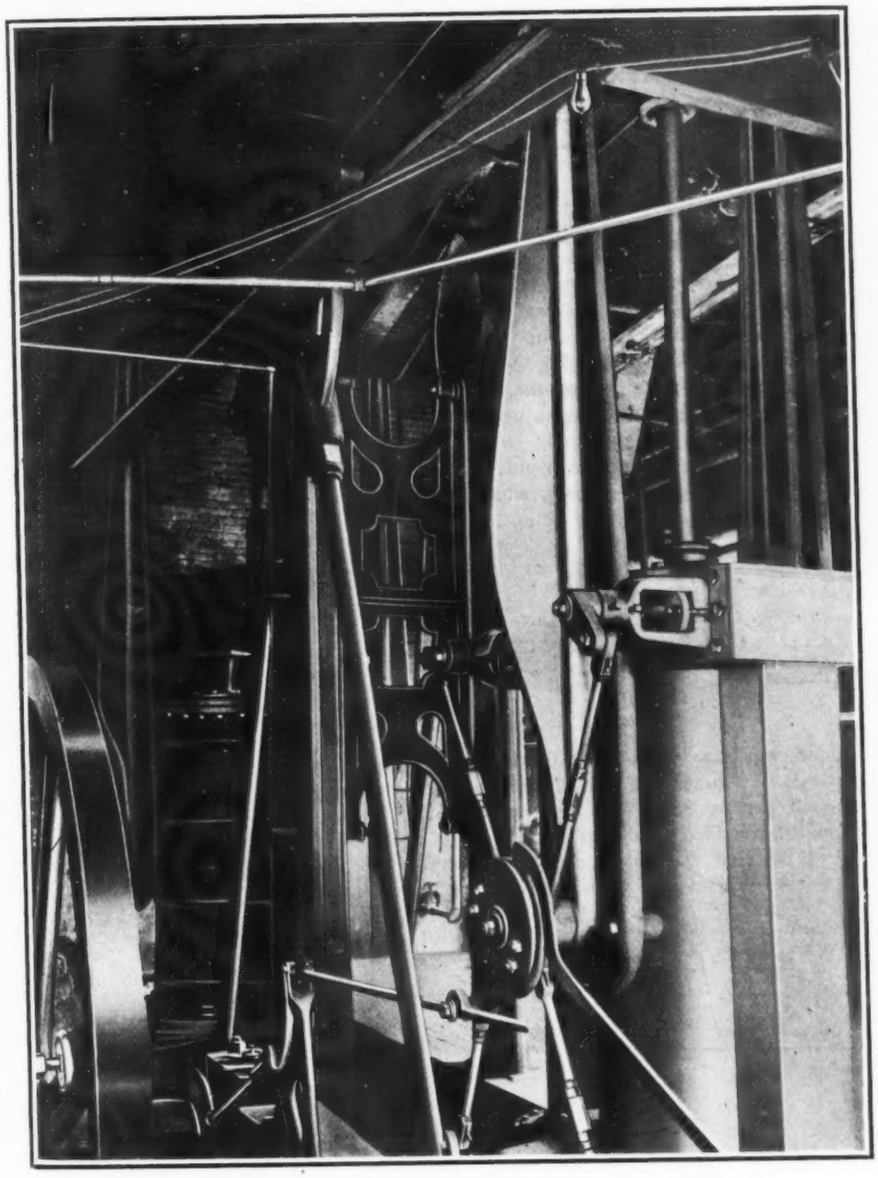
Where it is possible to use a floor covering without making it strictly proof against leakage, vitrified brick may be used to good advantage.

GEORGE W. MARTIN.

Pine Bluff, Ark.

An Old Engine

The subject of the accompanying photograph is an old engine now doing reserve duty in a 50-ton charcoal blast furnace, where it was installed back in the sixties. Previous to that it was used as a pumping engine for several years in a city waterworks plant, and when re-located the pumping end of the engine was changed into a blowing cylinder, for blast-furnace purposes. It has a heavy, square-rim flywheel, 18 feet in diameter, the dimensions of the rim being 10x8 inches. As will be seen, the beam is quite heavy; in fact, it really looks too heavy. The valve centers are 24 inches apart horizontally and 74 inches vertically, the cylinder being fairly long. The piston travel is 84 inches, so that it makes 14 feet each revolution. That multiplied by 20, the number of strokes per minute (which is easily attainable), makes 280 feet, which is not bad for an ancient machine.



AN OLD ENGINE

The steam cylinder is 84 inches long and 28 inches in diameter; the steam chest was cast on the side of the cylinder. The valve pockets are 21 inches long and the valves are each 5 inches in diameter. The piston-rod is 3¼ inches in diameter. It is supported by two heavy upright guides. The crank was coupled back 18 inches from the end of the beam, as, there being nothing on the shaft except the balance wheel, it was not deemed necessary to have as long a crank as otherwise. Beyond this was the original pumping end, now the air chamber. This air chamber is 54 inches in diameter. The engine operates normally under 3 pounds pressure per square inch, so that having a head area of 2290 square inches this amounts to 6870 pounds, and I am told that the engine has worked and stood at 8 pounds, which means 18,320 pounds on the end of the beam—quite a task, considering the age of the engine.

It is a four-valve engine, the valves being of the Corliss round type, all coupled directly to the wrist-plate. The valve gear can be uncoupled to allow the engine to be started and stopped off center. There is a very good rocker-arm arrangement. The speed being controlled by the throttle valve, it is in reality a four-valve throttling engine, a forerunner of the type which is now becoming popular. This engine is said to be much more economical than the poppet-valve engine alongside it.

C. R. MCGAHEY.

Cedartown, Ga.

"Jet Condenser and Centrifugal Vacuum Pump"

On page 796 of the November number there is a description of a new form of jet condenser patented by Burchard Thoens. This design of condenser seems very good in many respects, and particularly as it permits a saving of pipe, thereby doing away with the heretofore cumbersome and necessarily long condenser. I congratulate Mr. Thoens upon his design, but I would like to ask what provision has been made for water leakage, as I see no seal of any kind on the impeller of the pump to prevent the water from leaking, and, in time, filling the casing, a condition which would cause trouble if water should get into the steam exhaust. This may have been considered, and I presume it was, and the fact that the drawing shown is a reproduction of a patent-office drawing would account for its not being very precise. At least, I have known of its happening so before.

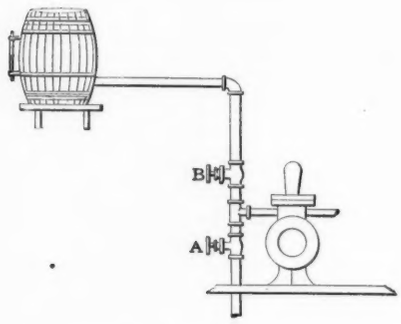
C. W. CLIFFORD.

Philadelphia, Penna.

Feeding Boiler Compound

In some steam plants the practice prevails of putting boiler compound into a boiler only when it is washed out, and once or twice a week while the boiler is in operation. I am very doubtful if this does much good. My idea is to feed the compound into the boiler every day, besides putting some in when the boiler is washed out.

The accompanying sketch illustrates a plan I used in a small plant for feeding compound. An oil barrel was cleaned and conveniently placed above the suction pipe of the boiler feed-pump. A pipe was connected from the barrel to the suction pipe of the pump, as shown. When the compound was to be fed to the boiler the valve *A* was closed, the valve *B* opened and a supply of compound pumped into the boiler. This was done once every day. The barrel was filled every Monday morning with enough compound mixed



MR. JAHNKE'S BOILER-COMPOUND FEEDER

with water to last the entire week. There was a gage glass at the barrel.

H. JAHNKE.

Milwaukee, Wis.

Rod-end Troubles

On taking charge of a small steam plant I found that the engine had a very bad pound in the crosshead, and constant keying did no good. I removed the adjusting bolts and found that the wedge was up so far that it allowed the brasses to work back and forth and produce the pound. In Fig. 1 *A* represents the wedge and *B* the space which permitted the end play of the brasses as the crosshead moved back and forth. The wedge was removed, a hard, brass shim was cut to the same size, and four holes were drilled in the shim for four flat-headed screws; corresponding holes were drilled and tapped in the wedge. After tinning the faces of the shim and the wedge, the shim was screwed into place. The two surfaces were uneven, so after the screws

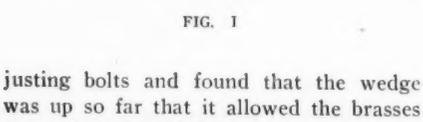


FIG. 1

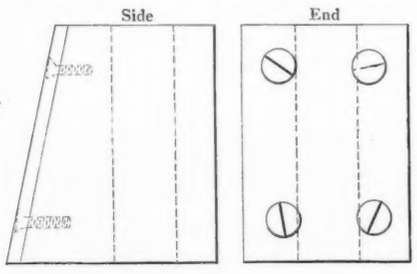


FIG. 2

were tightened as much as possible both shim and wedge were heated until the solder ran, when the screws were further tightened and the wedge allowed to cool. The manner of fitting the shim to the wedge is shown in Fig. 2. Fig. 3 shows the new wedge in place. After the engine was started up and the brasses properly adjusted the pound disappeared.

In another plant the wrist-pin gave trouble by cutting the brasses, which I

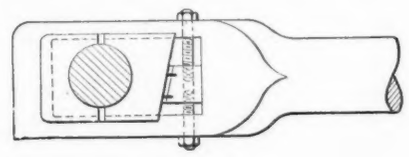


FIG. 3

decided was due to lack of lubrication, although the brasses never showed any signs of getting hot. The brasses were taken out and filed as shown at *A* and *B*, Fig. 4, so that the sharp edges on the brasses were prevented from scraping the

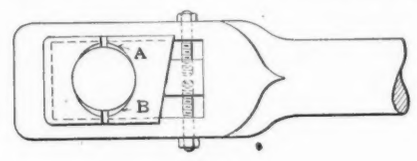


FIG. 4

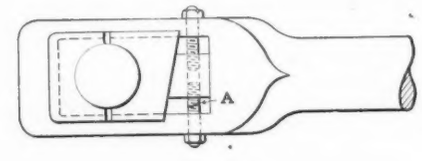


FIG. 5

oil from the wrist-pin. It is obvious that the pin received good lubrication after the brasses were replaced.

In another plant the adjusting bolt broke as shown at *A*, Fig. 5. The engine was of 300 horse-power capacity, direct-connected to a generator, and operated at 250 revolutions per minute, the brasses being adjusted by two bolts. The brasses would not remain adjusted, which led to an examination of the adjusting bolts. At first there was no indication that they were imperfect, but when closely examined the crack was found. The broken ends showed that the bolt had become partly crystallized, doubtless due to elongation of the bolt. After breaking several bolts in this manner, the brasses were changed for others having a different taper, and a wedge was fitted to correspond to the slant of the new brasses. The engine was put to work, and it was months before the bolts gave any trouble. It is evident that the bevel of the wedge had considerable to do with the breaking of the adjusting bolts.

ADJUSTING BOLT.

Cleveland, Ohio.

Simple Means for Removing Gage Indicators

Some engineers may have experienced difficulty in removing the indicating needle, or pointer, from a steam gage.

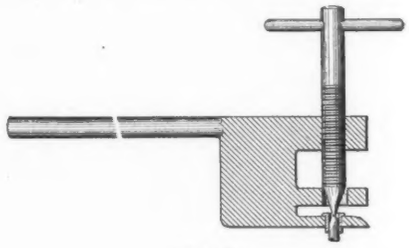


FIG. 1

To such is this letter directed. Part of one's leisure may be profitably spent making a tool which, for the purpose mentioned, will be more efficient than a screwdriver; such a tool is shown in Fig. 1. It is filed from a piece of bronze. A 3/16-inch hole is drilled in the topmost tongue, and tapped for a ¼-inch screw. The bottom tongue is slipped under the

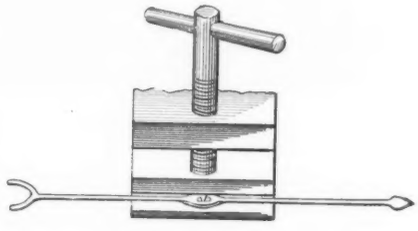


FIG. 2

pointer, as shown in Fig. 2, the end of the screw placed over the point of the pin, and the screw turned. This will remove the pointer without trouble.

J. BURNS.

Columbus, O.

Engine-room Experiences

Nine times out of ten a fight for economy must be begun in the boiler room, where there are more opportunities for improvement than elsewhere. On several occasions I have taken charge of large

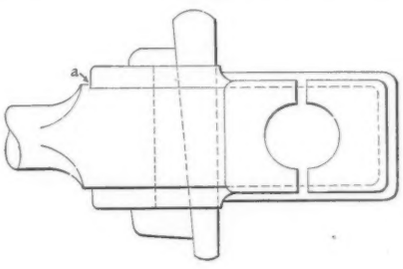


FIG. 1

plants where the boiler settings were so full of holes that sufficient draft could not be had through the grates, yet these sources of waste and worry had evidently escaped the notice of my predecessors, to whose eyes the dark-red flame meant nothing.

Recently I took charge of a plant

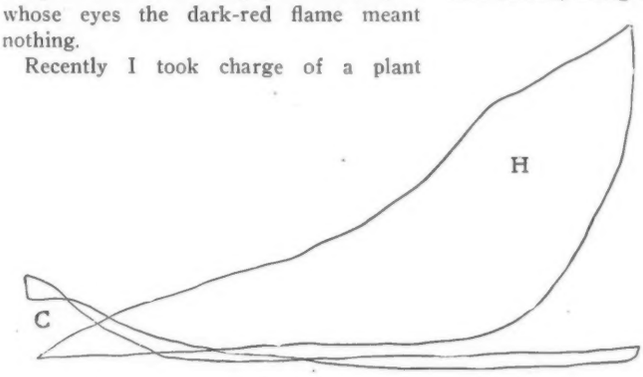


FIG. 2

equipped with two 400-horse-power water-tube and three 66-inch by 18-foot fire-tube boilers. The water-tube boilers were fired with shavings and dust and the fire-tube boilers with coal, about 10 tons of the latter being consumed each

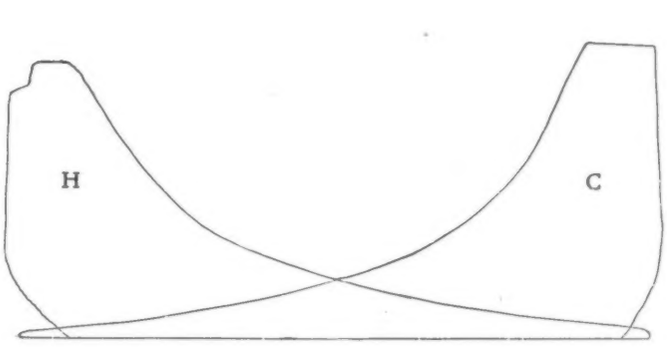


FIG. 6

10-hour day. There was a steam line of 5½-inch pipe, 325 feet long, through a tunnel five feet deep and three feet wide, the pipe being laid on the bottom where it could not be covered because it laid in water most of the time. I got a bricklayer to repair the boiler settings, raised the pipe about two feet and covered it with a non-conducting material coated heavily with linseed oil to prevent absorption of moisture. I instructed the firemen, all green men, in the proper method of firing, then I cut out the fire-tube boilers, doing away with the expense for coal and two firemen, and carried the load easily with the two water-tube boilers. This meant a saving of nearly $20 per day. The former engineer had told the firemen that once a week was often enough to blow the soot off the tubes and baffles of the water-tube boilers. Naturally, therefore, they had not steamed very freely.

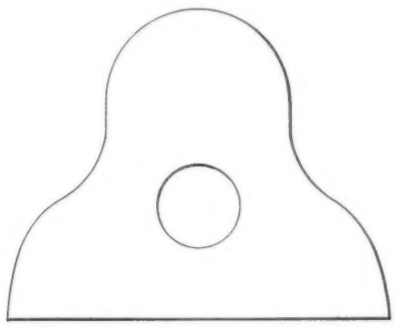


FIG. 4

In the main engine room was a 24x48 Corliss engine twenty years old, and the arrangement for screwing the straps to the stub ends of the connecting-rod is shown in Fig. 1. Long use had caused wear between the stub-ends and the straps, with the result that the gibs did not hold the straps firmly to the stub ends. I had liners cut and placed between the stub-ends and the straps, clear through over the brasses at *a*, both at

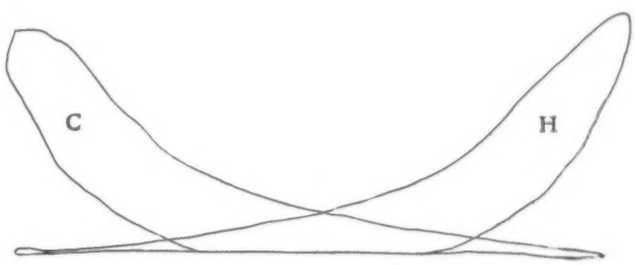


FIG. 3

the crank and crosshead. There had been a very annoying slap as the engine passed centers. This ceased and the engine ran very nicely.

We also had a 250-horse-power Erie automatic engine, which had bad knocks

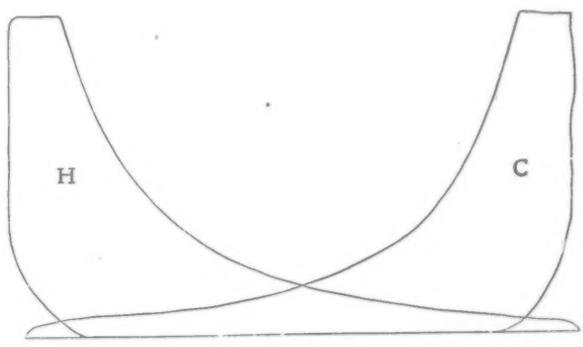
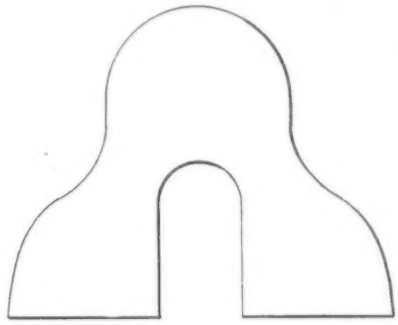


FIG. 7

in the crank and crosshead, as well as "slam" in the governor. The indicator produced the diagrams shown in Fig. 2. Correcting it, as indicated by Fig. 3, took



the knock out of the crosshead and the crank-pin, and closing up the eccentric-straps took the "slam" out of the governor. The liners which held the straps apart were like Fig. 4, so that in order to remove them to take up wear the back strap had to be taken off entirely, which is quite an item to a busy man in a hurry. I cut the remaining ones out like Fig. 5, so all that is necessary is to slacken the strap bolt-nuts slightly, remove the liner and tighten up again—the work of three or four minutes.

Fig. 6 is from a 14x42 Bates-Corliss engine which I was called upon to square up. The engineer had so much lap on the head-end valve that he could not get admission and cut-off right. The cam-rod was "too short." He said that without a new cam-rod the adjustment could not be made "mathematically correct." The diagrams, Fig. 6, also indicate leaks, and I found the valves badly cut. The engine had a "whoop" between exhausts that would put an Indian to shame. The engineer had not figured this out "mathematically" as yet. I lined the valves down by draw-filing and grinding with emery, and after squaring up the engine obtained the diagrams shown in Fig. 7.

WILLIAM WESTERFIELD.

Charleston, Mo.

Steam Engineering and Engineers

Steam engineering is a comparatively young science, but it has made very rapid progress, so that industries have been revolutionized by reason that power can be transmitted over any distance, to almost any hight and to any reasonable depth. The Niagara Falls have been harnessed; New York and Europe are within five or six days of each other, whereas formerly they were thirty days apart; the earth's treasures are brought forth, the oceans explored, rivers are bridged and tunneled, canals are constructed, the air is navigated and land is irrigated, reclaimed and traversed by steel belts. Monuments to warriors and statesmen are common, but monuments to Watt, Corliss, Isherwood and other founders and promoters of steam engineering are "*non est*," as far as my ken goes.

In former years the steam engineer was regarded as of the best type of skilled craftsman, and after serving his apprenticeship, acquiring such knowledge of maintenance, operation, etc., as can only be acquired from experience, he was awarded a license. A so-called "technical" education was not necessary—practical knowledge and rule-of-thumb methods prevailed. He performed his duties on *terra firma* and he lived longer and better than does his modern brother. Today the situation is entirely altered; the rapid advance in engineering compels the steam engineer to hustle, and when his daily toil is ended, he must study the mechanical periodicals or become a back number. The requirements of an engineer have been at least tripled. The engineer-in-charge in particular must possess the knowledge of construction, installation and operation of boilers, engines and their appendages, be conversant with electrical transmission and motor construction, able to do or to direct repairs on elevators, heating, hydraulic-thermostatic and what-not systems, have a good knowledge of chemical engineering and also be conversant with the indicator, the calorimeter and electrical measuring instruments, all the time remembering that an error on his part is liable to cause the destruction of hundred of lives.

He performs these duties, which produce the necessities, comforts and luxuries of life, in low-ceiled cellars, working constantly in the glare of electric light, surrounded by several elements of death. He may be burned, blown or suffocated to death; and many engineers are confronted by the slow death caused by long hours, seven days a week, and poor monetary compensation therefor. Employers should realize that accidents due to overworked employees are becoming numerous; Europe has already recognized the fact, but in America the chase for the mighty dollar is so keen that we entirely lose sight of safety. Not only are employees, and particularly engineers, pushed to the limit, but there is apparent an increasing laxity as regards building materials and construction; in fact, the laxity is so great that it becomes the duty of every engineer to sound the warning, if for no other reason in order that his own life and that of his fellow employees be not needlessly sacrificed.

G. J. M.

Brooklyn, N. Y.

Clever Way to Tighten a Blower Fan

A large fan in the heating system of a manufactory had become pretty shaky. All the rivets were loose and both spiders were so worn that they sat away from the shaft about half an inch. The shaft is 14 feet long and 5 inches in diameter.

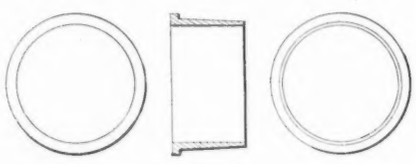


FIG. 1

Experts had declared that the spiders must be rebored and a new shaft put in. The fan couldn't be spared from service long enough for that, and besides it was too formidable an undertaking. Therefore, the plan illustrated by the accompanying figures was adopted at my suggestion.

Two taper brass sleeves were made for wedges, the inside diameter being just a

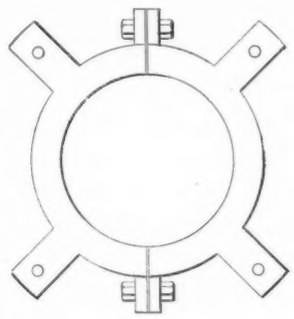


FIG. 2

trifle over that of the shaft, each with a flange on the thick end, as shown in Fig. 1. The sleeves were turned as one piece and cut in two. Then two cast-iron spiders were constructed in four sections, and the halves bolted together, as in Fig. 2. These were bored to fit loosely on the shaft. After slipping the cone sleeves under the hub of the fan, as in Fig. 3, the cast-iron spiders were put on, one on each side, and four ⅝-inch tie-rods, with threads and nuts on each end, were passed through the holes in the spider arms, going between the arms of the fan. Tightening on the rods drew up the spiders and wedged the sleeves solidly in place under the fan bearing without throwing the fan off center, or interfering with its functions, except to cause a brief shut-down while adjusting the various parts. The operation tightened everything up beautifully, and the fan has been run continuously for two years since without trouble.

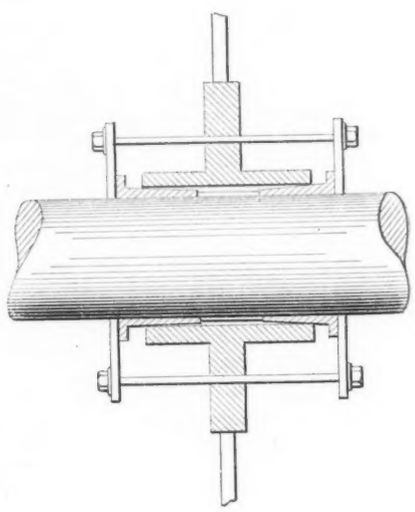


FIG. 3

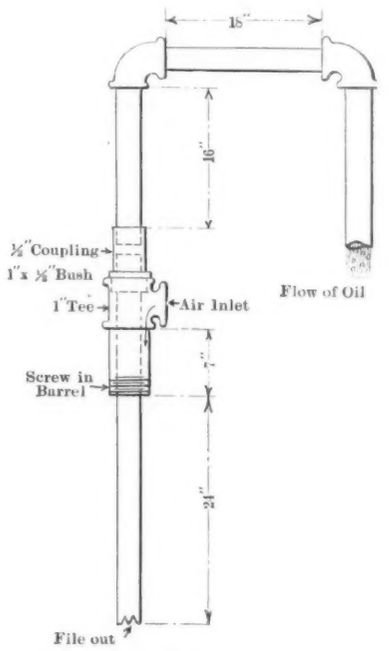
J. W. GRANT.

Worcester, Mass.

Pumping Oil with Compressed Air

Herewith is a practical idea which I have used quite a while with success. In this plant is handled considerable oil which comes in barrels. As it took a lot of time and caused more or less bother to pump it by hand, I conceived the idea of using compressed air, rather than go to the expense for a pumping outfit.

On one end of a 7-inch length of 1-inch pipe, threaded at both ends, was screwed a 1-inch tee, and a 1x½-inch bushing was screwed into one side of the tee. Next a long thread was cut on one end of a 35-inch section of ½-inch pipe, and in the other end were filed four notches ⅛ inch deep. This end of the



FOR PUMPING OIL WITH COMPRESSED AIR

long pipe was inserted in the 1-inch pipe and the threaded end of the ½-inch pipe was screwed into the bushing, ½ inch of the thread extending from the top to receive a ½-inch coupling. One end of a 16-inch section of ½-inch pipe, which was threaded on both ends, was screwed into the coupling, and an elbow was screwed on the other end. The side outlet of the tee was used for the air connection.

A 1⅛-inch hole is bored in the bung of the barrel and the free end of the 1-inch pipe screwed into it. The compressed air connection is made by means of a rubber hose, although, of course, any suitable means will do. By being careful not to use too great air pressure the device works "like a charm," and it will empty a barrel in five minutes as thoroughly as if drained.

J. Allan Wood.

Kingston, N. Y.

Lubrication of Engine Valves

The article on the above subject (page 685 of the October number) opens up a wide field of interesting study as to the best methods of lubricating the valves and cylinders of steam engines. The author's reasoning is evidently founded on certain exceptional conditions met with in his own practice, and he has built up a theory applicable to general purposes. He likewise condemns the practice of feeding oil into the steam passages, and with a great deal of plausibility he proves such a system to be lacking efficiency and economy.

It is well known that many oils, when raised to the temperature of the steam and kept at that temperature for some time will vaporize, that is, the oil will begin to distil and particles will separate out, leaving behind less oil than was ordinarily used. The portion that is vaporized, however, is not a lubricant and the oil is better without it, so that the mere vaporizing of the oil is not a serious matter. The thing of importance is the character of the oil that is left.

The oil company for which I am consulting engineer has conducted exhaustive tests in this direction and has found that many oils, when submitted to high temperatures for some time, lose only a small percentage by vaporization, while the rest of the oil comes out in the form of a thick deposit which hardens rapidly, and proves to have practically no lubricating value, notwithstanding that such oils, before being subjected to the high temperatures, appear to be good oils. On the other hand, many oils lose a large percentage under a high steam temperature, but that which is left is limpid and extremely good as a lubricant. It has also been found that the vaporization of an oil, whether little or much, is not a matter upon which one can base judgment as to its economy or efficiency, and in fact it is safe to say that it is of no great importance to the purposes of cylinder lubrication whether the oil vaporizes or not; what is wanted is an oil which, after it has vaporized—if it does so—leaves behind a limpid lubricant.

There is another point, however, to be remembered in connection with the vaporizing of oil under steam pressure, and this point cannot be too strongly insisted upon, viz, that the vaporizing point of an oil is raised to such a degree, due to the pressure of the steam, that it is practically impossible for a temperature to be reached, even with superheated steam, that will vaporize cylinder-oil. It is well known that high temperature is required to boil water under pressure, and engineers should remember that however low the vaporizing point of an oil when tested in the laboratory, the vaporizing point when in a steam passage or cylinder is considerably higher; and it should be borne in mind, when considering this question of supplying oil to steam passages, that the oil is neither vaporized nor volatilized, but simply atomized or broken up into a fine spray, and in such condition is carried everywhere with the steam. There is this important qualification, however: Wherever there is a cooler surface than the steam itself the oil flies to that surface, and moreover oil will adhere to whatever surface it touches and, indeed, is attracted to metallic surfaces rapidly. No pretense is made that such a system of lubrication is ideal, but certainly no other system approaches it in efficiency and economy.

As to the statement in the article referred to that the oil must be placed or forced between two bearing surfaces, or between the valve and its seat, it must be remembered that wherever there is a groove the oil will lodge in it and is likely to vaporize and dry up, and within a short period both grooves and holes would be blocked. Moreover the valve, if working on its seat under pressure due to its own weight and with some degree of slackness in the end bearings, enables the steam pressure to force it yet closer to its seat. There is, apparently, what might be termed a pressure that could be measured per square inch of the bearing, but any engineer knows that the pressure necessary to force oil into such a bearing is much greater than the actual pressure on the bearing, and all one has to do to prove this is to try and force oil into a big journal or through a cap at a locomotive axle. He will find out that a tremendous pressure must be used to get the oil to enter. In fact, it is doubtful whether the system suggested in the article has the elements of practical success even on the very smallest of engines, except in some peculiar and exceptional cases.

I have had considerable experience in overcoming difficulties in the lubrication of Corliss valves and have always found that if the oil is fed into the steam passages as near to the high-pressure admission valve as possible the lubricant will act perfectly. The oil is atomized in proximity to the valve, and the spray covers every part, the seat and valve receiving a supply of oil extremely minute, certainly, but in the course of a day's run the desired film is perfectly maintained by regulating the supply. With a well-designed sight-feed lubricator, the oil feed, if directed into the steam passage as near to the valve as possible, can be reduced to a minimum amount for valves and cylinders, and there will be so little of the oil left over in the steam that it may practically be ignored.

W. Scott Taggart.

Bolton, Eng.

Locomotive Boilers for Use in Restricted Quarters

As an example of crowding a boiler of maximum capacity in a space of minimum width the following is interesting. At a power plant in Pennsylvania the boiler room was designed for four 150-horse-power horizontal return-tubular boilers, with standard brick setting, leaving a narrow space on each side between the setting and the wall. Later it was found necessary to add at least 80 horse-power to the original installation. The space between the setting and wall on the right could not be utilized, as it gave the only access to the engine room, hence the only available space was that on the left side, which had a clear width of 4 feet 3 inches. It was decided that the most economical type of boiler adaptable to the conditions would be a locomotive boiler. One was purchased, in accordance with the following general specifications:

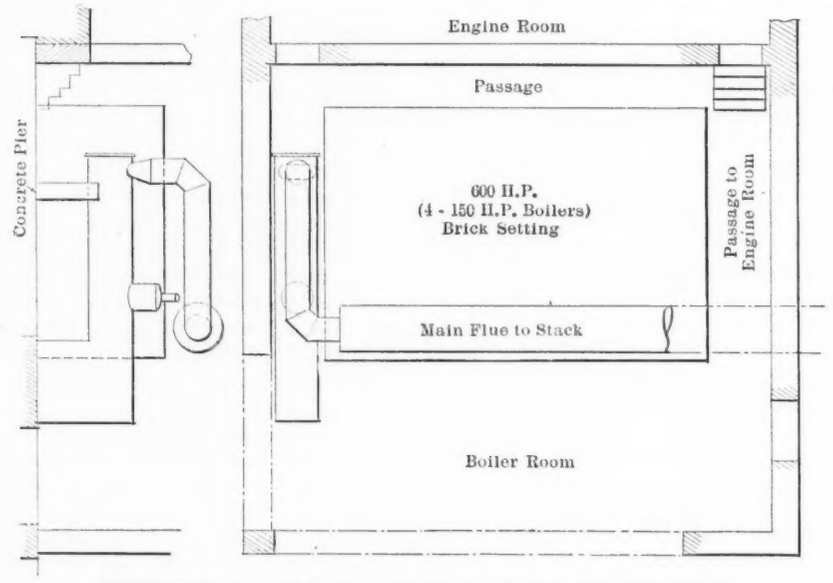
Total length, 25 feet 9 inches; maximum diameter of cylinder or barrel, 4 feet; hight of fire-box, outside 8 feet 8 inches, inside 5 feet 9 inches; inside length of fire-box, 5 feet 6 inches; width of fire-box (inside), 3 feet 4 inches. The boiler to contain seventy 3-inch standard-gage charcoal-iron tubes, adapted to a working pressure up to 125 pounds and capable of withstanding 189 pounds hydraulic-test pressure.

As there was no available space for ash-pit walls the sides of the wagon top and the front head and throat-sheet of the fire-box were extended and footed with an angle-band on the inside to form an ash-pit, being lined with fire-brick to prevent deterioration from wet ashes. A door was located in the ash-pit extension of the throat-sheet to give access to the space beneath the cylinder at the rear. The water-leg ring was flanged to Ogee shape from a solid plate.

This boiler gave an actual rating of 85 horse-power, or 5 horse-power in excess of the requirement. It was constructed at the Coatesville Boiler Works, under the supervision of the writer.

REX C. WILSON.

Coatesville, Penn.



BOILER-ROOM LAY-OUT, SHOWING LOCATION OF LOCOMOTIVE BOILER

How Centrifugal Force Affected the Oiling Device

Following is an incident which happened when I was an oiler. The oiling device for the crank-pin is shown in Fig. 1 herewith, and while the wiper shown at *C* would catch the drop very nicely as it formed at the tip of the pipe *B*, the amount of course was limited, and in case of a hot bearing there was no means of increasing the flow; so the "master mechanic" went about to "improve" on this arrangement by having this wiper made as in Fig. 2. The result was puzzling to both of us. I could not see how in the world I managed to get any oil to that pin at all, and he was surprised that the thing did not prove the success he expected it to be.

R. CEDERBLOM.

Chicago, Ill.

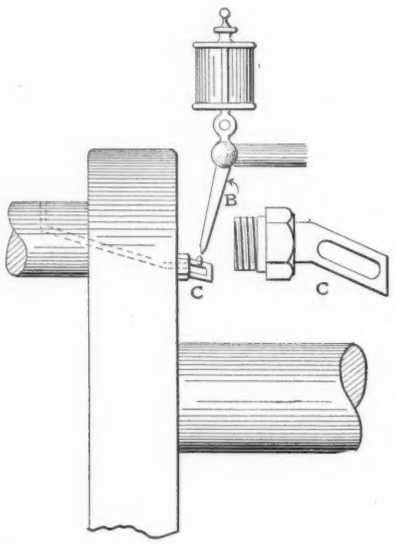


FIG. 1

This Engine Was Practically Made Over

Some time ago I went into the country to repair a small engine used for sawing wood, cutting feed, etc. I found that the packing consisted of one split ring, about 1½ inches wide, with the ends tongued and grooved. This ring was very loose and the nut partly off, allowing the ring and follower-plate to work back and forth about a quarter of an inch. There was a plain D slide valve with a square lug cast on the back of it; a yoke made to fit over this lug and the valve-stem screwed into it with a nut and a lock-nut to keep it from becoming lose. The yoke had been repaired with wire apparently taken from the chicken-yard fence. The valve-stem extended down through the stuffing-box and also through a hole in the casting of the frame, thus serving as a guide to the rod. The hole in the casting was badly worn. The eccentric-rod was connected to the valve-rod by means of a clamp.

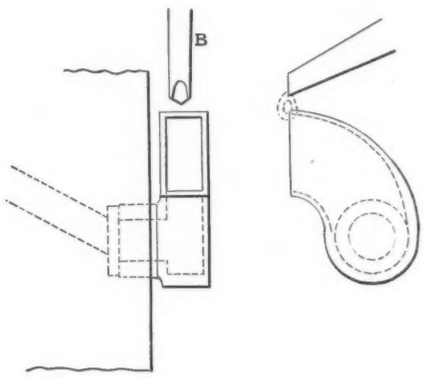


FIG. 2

I sent the ring in the cylinder to the shop to have a new one made and took the valve-stem to a blacksmith. I had a new wrought-iron yoke made, drilled it and tapped it for the valve-rod; then I filed the yoke to a nice working fit on the lug of the valve. I had the lower end of the valve-rod made square, and cut the casting away clear to the round guide hole, which I filed square to fit the end of the valve-rod; then I fitted on a plate with two cap-screws to hold it in place. By fitting the guides in this manner it

prevented the twisting of the valve-rod by reason of the motion of the eccentric.

The crank-pin brasses were found to be brass to brass and badly scored. I filed off the edges to allow the curved surfaces to come closer together and filed and scraped them out. I then draw-filed the pin and finished it with emery cloth.

While looking at the crosshead-pin I noticed that the guide seemed rather loose. This guide consisted of one square bar held by clamps at each end, with two bolts in each clamp. I found both of these clamps broken on one side, and therefore held by only one bolt each. I had two new wrought-iron clamps made and put them on in place of the broken ones. We then connected up the rod and proceeded to put the new rings in the cylinder. Instead of one ring 1½ inches wide we made two rings, each ¾ inch wide, placing the cut in one ring on one side of the piston, and the cut in the other one directly opposite with a 1½-inch expansion ring underneath the two. We replaced the follower-plate and cylinder cover and got up steam.

When the pressure had risen to 90 pounds I filed a slot in the safety-valve lever so the weight could not slip and sent the pressure up to 130 pounds. When pushed hard, the engine slowed down a little, due in a measure to the fly-wheel being too small, but otherwise it worked very well.

An old pulley 36 inches in diameter and 7 inches in face was found, and after fitting a new bushing it was substituted for the fly-wheel, and the belt lengthened. That completed the repair satisfactorily.

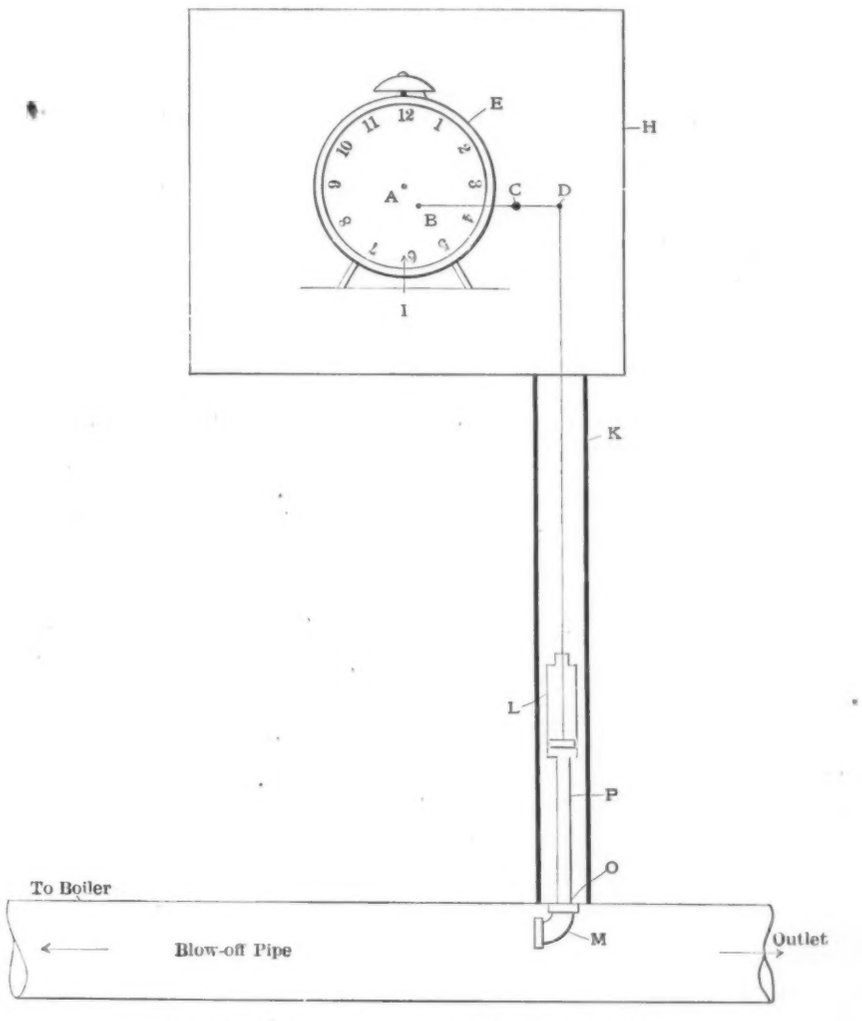
C. H. T.

Bridgeport, Conn.

"How to Tell Whether a Boiler Has Been Blown Down"

In the October number, on page 701, T. B. Rice & Sons Company asks if there is any way of telling when a boiler has been blown down. I think any pressure-recording gage would serve the purpose, as even ten or twelve boilers could be connected to a gage-pipe back of the blow-off valves, with cocks in the pipe set to accommodate the different pressures. Then by having a fixed time for blowing one could tell at a glance if it were done.

We once used a home-made device with good results on three 72-inch return-tubular boilers. A tin disk 12 inches in diameter was soldered to the hour hand of a small clock and a piece of paper secured to the disk by four spring clasps such as are used on suspenders. On the paper were printed numerals representing the hours. There was a tee in the blow-off pipe, and the plug on the end was drilled and tapped and a 7-inch piece of ½-inch brass pipe connected to it. Inside the pipe was placed a rod, with a long thread on the end, on which a nut, iron washer and leather-cup washer were placed, the iron washer being set in the cup with the nut holding them in position. Back of the first washer was placed a coil spring, resting against a washer in the reducing coupling, to return the pencil after the pressure left the piston. On the other end of the rod there was an eye just large enough for a lead pencil to be pressed into. The device worked as follows:



MR. NOBLE'S SUGGESTION FOR A BLOW-OFF TELLTALE

The pencil pressed against the paper on the tin disk which was carried around by the hour hand. While the blow-off was open the pressure caused the pencil to cross the paper horizontally and the coil spring returned the pencil in an oblique direction as the blow-off closed. The space between the open ends of the lines thus traced indicated the length of time the blow-off was open. The three boilers were connected so that each pencil started in a different place.

D. F. C.

East Boston, Mass.

Although I have never seen anything resembling the arrangement shown in the accompanying sketch, there seems to be no reason why it would not serve to show whether a boiler has been blown down, and it ought not to cost much to rig up. In a box *H*, which would have a glass front and a locked door, the key of which could be carried by the chief engineer or superintendent, is a small clock *E*, with the hands removed. A special dial from which the pencil marks can be erased or washed off would have to be made and fastened permanently to the hour-hand shaft at *A*, so the dial will revolve. At *I* a pointer is fastened to the clock frame; at *M* is a ¼-inch elbow (or a slight bend in the pipe might do, but it must be steam-tight at *O*); at *L* is a small cylinder connected to the pipe *P*, with a rod having a small piston on the end, extending upward through the box and joined, by means of a loose pin *D*, to an arm; the arm works on a pivot *C*; a lead pencil is secured to the end of the arm at *B*; at *K* is an outside casing to inclose the rod so that it cannot be tampered with.

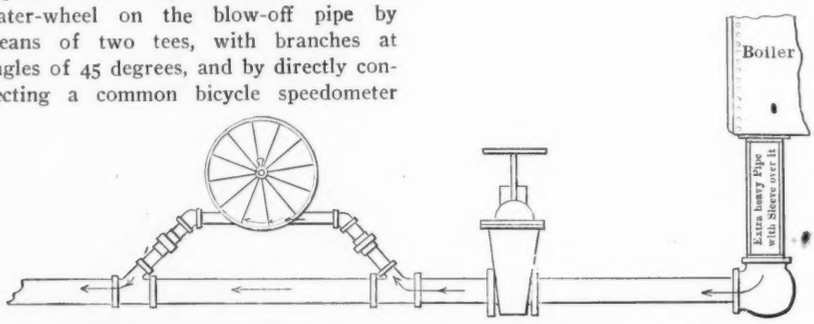
When the blow-off cock is opened, the water rushing along the blow-off pipe will enter the elbow *M* with enough force to

raise the small piston, which will communicate the motion to the arm and cause the pencil to trace a line on the dial as the dial revolves. This will not only show how many times the boiler has been blown down during twelve hours, but it will also show at what hour it was blown down.

JAMES E. NOBLE.

Toronto, Can.

The accompanying sketch will almost explain itself. By attaching a small water-wheel on the blow-off pipe by means of two tees, with branches at angles of 45 degrees, and by directly connecting a common bicycle speedometer



MR. BORENZI'S PLAN FOR TELLING WHETHER BOILER HAS BEEN BLOWN DOWN

to the shaft of the water-wheel, a reading will be obtained from time to time as the boiler is blown down. Personal experimentation will enable one to learn readily the approximate amount blown down by subtracting the last reading from the preceding one. For instance, if while blowing down 5 inches of water the speedometer has run from 100 to 700, it will indicate that the speedometer has to swell its figure by 600 in order to lower the boiler level 5 inches.

A SUBSCRIBER.

Somerville, Mass.

An apparatus which would indicate the times at which a boiler is blown down, as suggested by T. B. Rice & Sons Company, would be a good thing. We have twelve Babcock & Wilcox boilers of about 500 horse-power each. They shut down at one o'clock in the morning and start up at five. The fires are broken up about four o'clock. Immediately after one o'clock the fireman begins to pump up the water and between three and four in the morning all the boilers are blown down two gages, while the water is still and there is the best chance to carry off sediment. With very dirty water it may be necessary to blow down several times a day.

ED. H. LANE.

Kansas City, Mo.

Why the Steam Line Falls in the Diagram

In reply to "Assistant Engineer's" letter on page 708 of the October number, I think that the reason his steam line does not keep up better is wire-drawing, due to the slow closing of the valves. He states that his valve-gear is of the non-releasing type. With the releasing type of gear valves continue to open wider and wider until the point of cut-off is reached, when they are released and close quickly, making a sharp, clear cut-off. With the non-releasing type they must necessarily begin to close a great deal earlier, in order to close at the same point. Consequently, the port is gradually growing narrower and narrower, retarding the flow of the steam and causing the steam line to fall before the closing point is reached.

The difference in the initial pressure in the light-load diagram may be caused by various conditions. The connections leading from the cylinder may have been obstructed, or if the indicator were connected near the head end the steam from the crank end would have to travel through a longer passage to reach the indicator, and low pressure and, possibly, a small pipe would naturally tend to reduce the pressure. The pipe would have to be very small, however, to produce the condition shown in the diagram.

As he has only given the boiler pressure for one diagram, I suppose that it was the same for both. If so, his governors affect both the initial pressure and the cut-off, and that is a type of valve-gear that I have never seen.

One thing not generally known among engineers is that the valves on a non-releasing type cannot be set to cut off at the same point for each stroke, without affecting the admission. This is caused by the angle of the connecting-rod. When the engine is on center—the center nearest the cylinder, for instance—the distance from the piston to the crank equals the length of the connecting-rod, crosshead and piston-rod, and when the piston begins to move forward it commences to draw nearer to the crank until the greatest angle is reached, when the crank is on half stroke, or the perpendicular. The piston will then be found to be nearer the crank end of the cylinder than the head end, or in other words it has traveled more than half the stroke, the distance being the difference between the base and hypotenuse of a right-angled triangle whose base equals the length of the connecting rod, crosshead and piston-rod, the perpendicular equaling the distance from the center of the crank-pin to the center of the shaft.

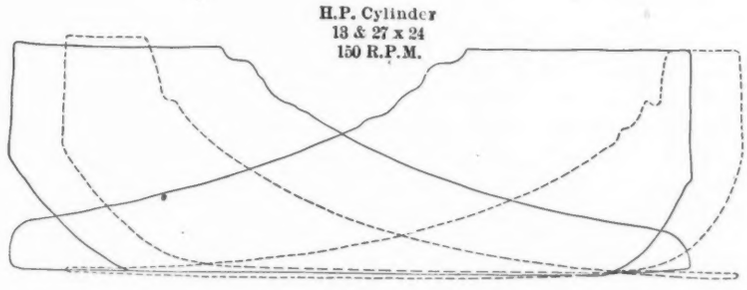
On the return stroke, when the crank has traveled half its distance the piston will be found to be in the same position and has traveled less than half the stroke. The valves, getting their motion from the eccentric, will close when the crank has reached the point at which they are intended to close, regardless of the position of the piston. Consequently the engine will always work steam farther on the forward stroke than on the return, the difference being greater at half stroke and less for earlier or later cut-off.

A. G. DAVIS.

Welsh, La.

In the first place I would say that a Corliss engine of the non-releasing type, with an inertia governor, is converted from a four-valve to a three-valve or a single-valve engine, with independent exhaust, the admission and exhaust being accomplished with the same eccentric. Consequently the load varies with the point of cut-off, due to the arc described by the eccentric actuated from the fulcrum pin. The port opening being so small and slow on the short cuts, the initial is necessarily reduced.

The accompanying diagrams are from a four-valve engine with independent cut-off, operated by a shaft governor. They readily show the difference between a three-valve and a four-valve engine.



DIAGRAMS SUBMITTED BY MR. WICKER

W. D. WICKER.

Alexandria, Va.

One reason for the falling of the steam line in the diagrams may be that the steam line to the engine or the area of the steam inlet ports is too small. The engine is running at about 150 revolutions per minute, and with a piston speed of 750 feet. If the steam pipe to the engine is large enough, then look to the steam valve and its port.

In the light-load diagrams the same rapid falling away of the steam line is shown, but the initial pressure is much lower. If the indicator cock is not open all the way, or the little globe valve on the indicator piping, a diagram such as shown by the crank end for the light load will result. On the full-load head-end diagram the exhaust valve seems slow in opening.

J. I. B.

Allentown, Penn.

Exhausting into the Suction of a Centrifugal Pump

The centrifugal pump problem by G. W. Wright, on page 701 of the October number, seems simple. There is a pump company which puts a deflecting valve on its pump so that the exhaust may be turned into the suction of the pump at will, and diagrams are shown in the catalog, giving a considerable vacuum in the cylinder. To prevent water from going into the cylinder a check-valve is used between the pump suction and the exhaust valve. The experience that I have had with turning the exhaust into the suction has been that the air and non-condensable vapors have given considerable trouble.

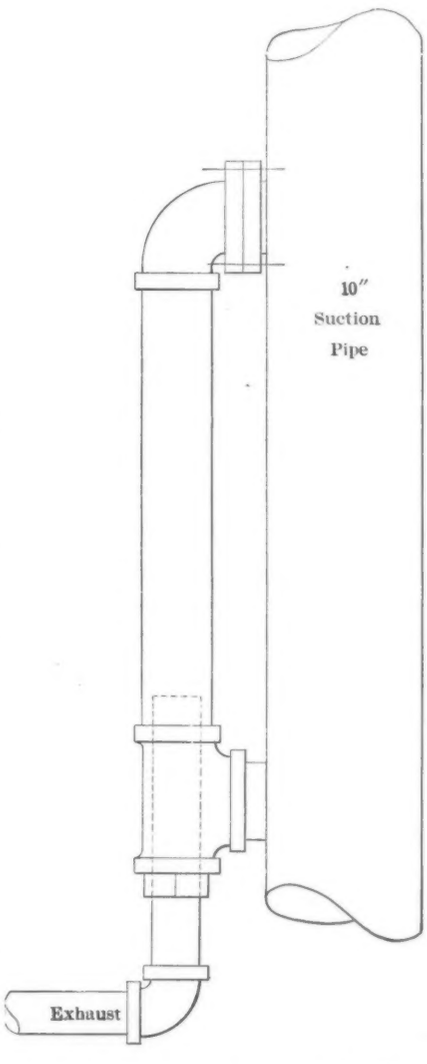
ED. H. LANE.

Kansas City, Mo.

It would be quite practical to connect the exhaust from a 9x10 automatic engine into the suction pipe of a centrifugal pump, providing certain precautions are observed. In the first place it will be necessary to have a bypass so the steam can be exhausted to the atmosphere when starting the pump; then when everything is in running order the valve connecting the suction pipe can be gradually opened, and as soon as the issuing exhaust steam is reduced to a small amount the exhaust valve can be closed and the whole of the steam discharged into the suction pipe.

To overcome serious water hammer and avoid choking the full delivery of a 10-inch suction pipe by discharging large volumes of steam into it, which would disturb the even flow, I would suggest piping it as shown in the accompanying sketch, causing the water to flow in the same direction, and all around the steam, as it issues from the exhaust pipe.

In case the pump should stop while the engine continued running there would be no danger of the momentum of the water in the suction pipe being sufficient to force the water back through the exhaust pipe into the engine 30 feet above. The water in the discharge pipe could flow back and if there is a foot-valve in the centrifugal pump it would possibly flood the engine after it was stopped, but it could not do so while running, because the steam would be discharged much faster than it could be condensed; in fact, it would build up pressure enough to force its way through the exhaust pipe to the discharge line and eventually escape there, causing extra back pressure on the engine. In case the pump, through any cause, should stop running, open the bypass and allow the steam to escape through the open exhaust.



HOW TO PIPE EXHAUST INTO THE SUCTION

Before shutting down it would be necessary to at first close the valve leading to the suction pipe part way, then slightly open the bypass valve to atmosphere, and thus alternately close one and open the other, without allowing enough air to leak in to interfere with the running of the pump, until the whole of the exhaust is discharged to the atmosphere. This would prevent a vacuum forming in the cylinder, which would suck up the water and cause flooding.

The gain in steam economy would certainly more than compensate for the loss in feed-water heat, assuming that the boiler only supplies this engine. Assume 25 pounds to be the amount of water consumed by the engine per horse-power-hour, when running non-condensing, the boiler generating 9 pounds of steam at 100 pounds pressure, with the feed-water at 210 degrees. The heat absorbed per pound of coal would be:

With one pound of steam at 100 pounds per square inch.....	1185 B.t.u.
With one pound of water at 210 degrees	178 B.t.u.
Heat added to the water to produce the steam.....	1007 B.t.u.

Then, $9 \times 1007 = 9063$ B.t.u., the number of heat units utilized per pound of coal. The engine is developing, say, 30 horse-power, and using 25 pounds of water per horse-power-hour makes a total consumption of $30 \times 25 = 750$ pounds of steam, and as each pound of steam means 1007 heat units the engine is using $750 \times 1007 = 755{,}250$ heat units per hour. From each pound of coal we are able to utilize 9063 heat units, therefore, $755{,}250 \div 9063 = 83.3$ pounds of coal per hour.

When running the engine condensing under about a 22-inch vacuum, the water consumption should be reduced to about 20 pounds per horse-power-hour, and in this case we would have $30 \times 20 = 600$ pounds of steam per hour consumed by the engine; this is 150 pounds per hour less than before. But, considering the boiler feed, with water at, say, 60 degrees, the heat required per pound of steam will be:

With one pound of steam at 100 pounds per square inch.....	1185 B.t.u.
With one pound of water at 60 degrees	28 B.t.u.
Heat added to the water to produce the steam.....	1157 B.t.u.

Then, consumption of the engine will be $600 \times 1157 = 694{,}200$ heat units, which divided by $9063 = 76.6$ pounds of coal per hour, a saving of 8 per cent. in the coal bills.

However, if a feed-water heater is used there is no reason why the exhaust should not still go through it and get the advantage of the heat. Of course, the temperature of the steam when running condensing will only be about 150 degrees and possibly would only heat the feed-water to about 100 degrees. A still greater saving is now possible for with feed-water at less than 120 degrees it is possible to use an injector and save all the steam that has been used by the feed-water pump, and in this way a total saving of approximately 10 per cent. might be looked for.

GEORGE P. PEARCE.

Buffalo, N. Y.

A good condensing system can be produced by piping the engine exhaust into the suction side of the pump line, but it will necessitate the use of a relief valve to allow the exhaust to escape to the atmosphere and a check-valve to obstruct the water from flowing back to the engine cylinder should the pump fail.

Some arrangement must be provided to mingle thoroughly the steam with the water at the point where the two combine.

With such an arrangement there ought not to be any difficulty experienced from water hammer or by a partial destruction of the vacuum due to hot water, inasmuch as there is more than 900 times as much water flowing in the line as exhaust steam and water of condensation.

The hot water for boiler feed need not be sacrificed, as an inclosed type of heater can be placed between the pump and the engine in the exhaust line, the proper place being between the engine cylinder and the relief valve. The feed-water may then be heated whether the engine is running condensing or non-condensing.

The check-valve should be positive-acting and should be located between the pump and the relief-valve.

B. C. A.

Dannemora, N. Y.

The letter in the October number, on page 701, regarding connecting the exhaust of a 9x10 vertical engine to the suction pipe of the pump, thus using it as a condenser, caused a great deal of discussion in our office, and it is the final decision that such a scheme would cause an air pocket and break the suction, due to the fact that a large amount of air would come over with the steam.

The amount of air or other gases which will pass through a centrifugal pump without "breaking the suction" is really surprising, as we have known of a number of instances where centrifugal pumps were pumping from driven wells where a large amount of marsh gas, etc., came over with the suction water and it did not seem to trouble the pumps at all.

It is our opinion that the gain in steam economy would not much more than compensate for the loss of feed-water heating which would be secured by putting the exhaust in the hot-well or into a standard feed-water heater.

X. Y. Z.

Buffalo, N. Y.

Replying to Mr. Wright's inquiry, the case will depend upon certain circumstances which he has not stated. Exhausting into suction pipes has been done with pumps with ordinary valves, but his case is somewhat different. Centrifugal pumps have to be arranged in a certain way to insure their working. His plan will be successful and safe if the pump discharge is near the pump, without any great length of discharge pipe to contain water; or if there is a retaining or check-valve in the discharge pipe at either end, or if there is such a valve in the suction immediately below the pump, which is a less common design than the other. The exhaust must be put in below this valve, however. It will be dangerous if there is a foot-valve at the bottom of the suction, or a retaining valve anywhere below the exhaust entrance.

In short, it will be safe if there is a retaining valve above the exhaust, but dangerous if there is one below it.

It is unsettled, in view of unexplained wrecks, whether it is safe to depend upon a check- or back-flow valve in the exhaust pipe leading to the suction, but some pumps have been run in that way without trouble.

Some importance attaches to the form of connection through which the steam is to enter the water; in some cases a plain tee works, but in others it does not. It is better to provide a favorable entrance for the steam, similar to a steam siphon or a simple jet condenser, the form and dimensions of which are important also. The action should be smooth and steady, without hammering.

I have operated several powerful slide-valve engines exhausting into water in this manner very satisfactorily, although there were several which could not be made to do so.

F. R. Williams.

Syracuse, N. Y.

I would answer Mr. Wright's questions by asking another: How would he start the engine and pump? Suppose the exhaust of the engine were piped into the suction of the pump and an attempt were made to start. Before the engine got up to speed and the discharge valve to the pump opened he would have a high back pressure and would lose the vacuum and the water to the pump, and it would be impossible to again prime it on account of the steam and hot water.

Again, suppose a valve were placed in the exhaust between the engine and the suction and another valve to provide exhaust from the engine to atmosphere. Then try to work the valves so as to turn the exhaust from the atmosphere into the suction of the pump without losing the vacuum on the pump. If one should happen to accomplish the feat (which I very much doubt), the steam would then be going into the suction of the pump in chunks, so to speak, and one would think he was pumping cobble stones. The noise would be terrific.

C. C. Webster.

Schenectady, N. Y.

"Modern Safety Devices for Prime Movers"

In the October number, beginning on page 680, C. C. Major describes certain speed-limit devices. While discussing the types presented quite extensively, he does not touch upon one or two points of extreme importance. The devices described are unquestionably of great value in many cases, but there are other cases in which the unexpected shutting off of the steam may lead to results at some other point more disastrous than the bursting of the fly-wheel itself. No one appreciates the desirability of speed-limiting devices more than the writer, who has been instrumental in having several adopted, but it is a question whether the indiscriminate stopping of the engine because the governor weights happen to fall below a certain point, or the speed increases slightly, is the best way to attain the object. It is much like a traveler in the middle of a long journey shooting his horse because he balks or runs away.

There are certain speed-limit devices to be had which do away with this feature entirely, being virtually secondary governors which come into action and prevent the admission of steam to the engine when the speed becomes abnormal, and automatically open the supply again when the speed has moderated to normal. In large central stations this is about the only type it is safe to use, as the result of stopping the admission of steam to a large direct-current generating unit operating in parallel with other units would almost inevitably be the reversal of polarity of the generator and consequent knocking out of circuit-breakers; or a still worse possibility is that if the circuit-breakers fail to operate the generator will run as a motor, and the current flowing in the wrong direction through the series fields may cause a destructive increase in speed, the conditions then resembling those wrought in a series motor with practically no load.

Even with the interlocking device sometimes applied for automatically tripping the circuit-breaker when the throttle is closed, interruption of service may occur from the sudden overloading of the other units, causing their circuit-breakers to open. In the case of industrial power stations this may mean such consequences as theater panics from the sudden extinguishment of lights, elevators being installed between floors, ruin of products by stoppage of factory and mill machinery, asphyxiation from stoppage of ventilating apparatus, and, worst of all, from some managers' point of view, loss of business. In electric-railway operation, grade-crossing accidents and collisions are a frequent corollary of unexpected stoppage of currents. In rolling

mills, steel works and foundries the element of personal danger from failure of power supply is, perhaps, hardly as great, but life there is held so cheaply and the financial losses may be so immense that the management would welcome a bursted fly-wheel and a dead engineer or two as an inexpensive excuse for the loss.

In the case of a cylinder head being knocked out, or persons being caught in the machinery, the addition of a plain, electrically operated valve, with parallel remote-control apparatus, could be used instead of certain speed-limit devices, with an added advantage of being able either to stop the machinery entirely, or merely slow it down and then bring it up to normal speed again without entire stoppage.

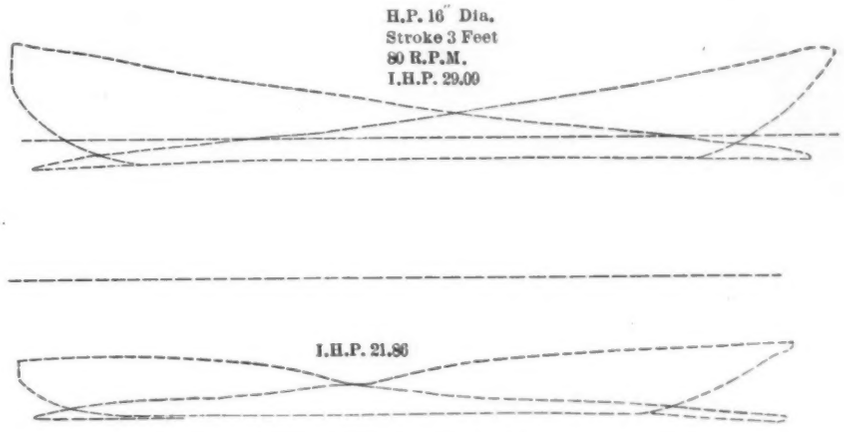
H. R. Mason.

St. Louis, Mo.

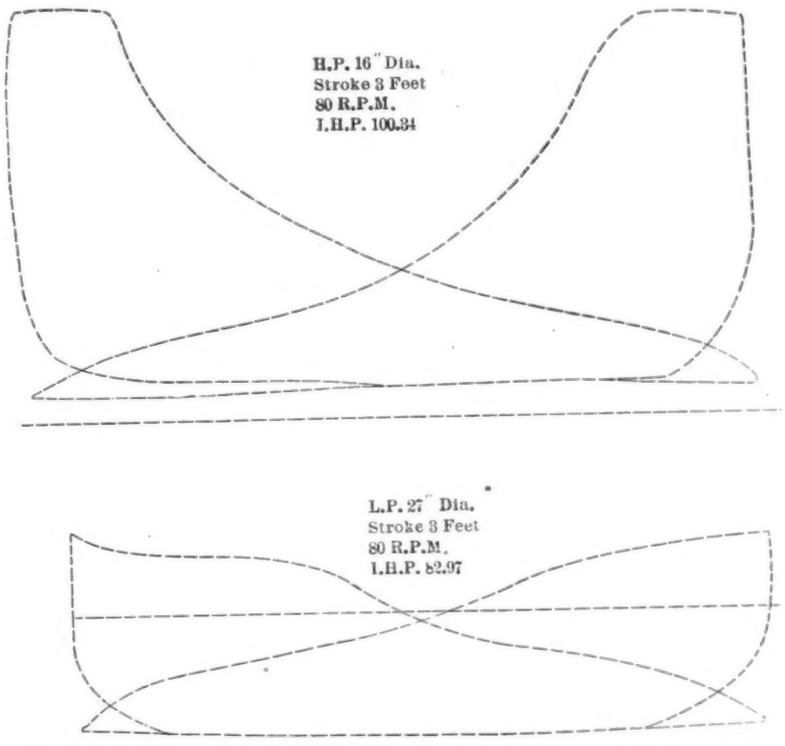
"Power Required to Drive Cotton-mill Machinery"

Several months ago (in April) I saw a letter by J. Creen about the horse-power required to drive cotton-mill machinery, as well as the frictional power of the engine and gearing. The mills he referred to apparently greatly differ from Indian cotton mills spinning generally from 16 to 30 counts. Mr. Creen says that taking the average horse-power of a large number of cases 0.137 of the indicated horse-power was required to run the engine, and, on the same basis, for 250 indicated horse-power, 34¼ horse-power would be required to run the engine at 50 revolutions per minute, with all the machines thrown off. I have found during my experience that the frictional power required by the engine, shafting and rope-drives, and all the belts on loose pulleys in a cotton mill, amounts to from 29 to 35 per cent., this variation depending upon the style of engine and gearing and the care and lubrication.

I submit herewith indicator diagrams from a vertical cross-compound condensing Corliss engine designed to develop 250 indicated horse-power, which used to run the following machinery:



FRICTION DIAGRAMS



INDICATOR DIAGRAMS FROM A VERTICAL CROSS-COMPOUND CONDENSING CORLISS

1 Thread extractor,
1 Willow,
1 Bale breaker,
1 Horizontal double-beater opener,
3 Single-beater switches,
17 Flat cards,
5 Roller cards,
3 Drawing frames, 6 deliveries each,
3 Scrubbing frames, 72 spindles each,
4 Intermediate frames, 112 spindles each,
7 Roving frames, 144 spindles each,
2 Roving frames, 120 spindles each,
18 Ring frames, 5856 total,
30 Hand reels,
5 Power reels,
2 Bundle presses,
1 Bale press.

These machines required from 175 to 190 indicated horse-power. The bundle and bale presses were not in constant use.

Mr. Creen gives 60 ring spindles (including preparatory machinery) for one indicated horse-power, including 10 per cent. allowance for frictional resistance of shafting. According to his calculation the total would be nearly 97.6 indicated horse-power, say about 100. In that case, what becomes of the other power? The writer has never heard of such a low requirement, but during a long experience in India he has found that from 36 to 40 ring spindles (including the preparatory machines) would require one indicated horse-power.

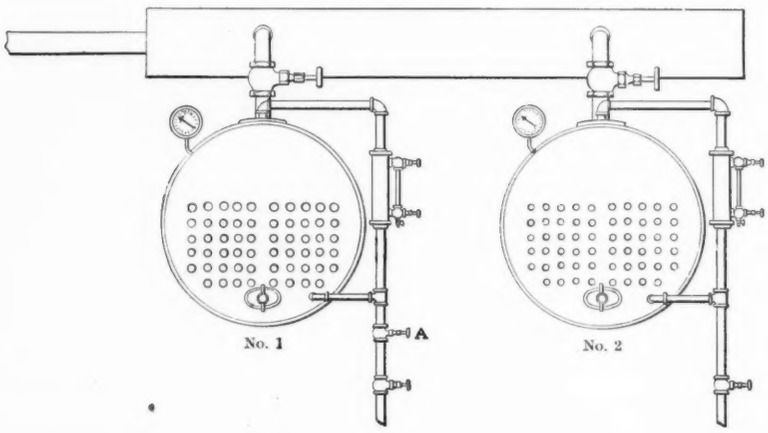
P. P. T.

Ahmedabad, India.

"Blow-down Valves on Water Columns"

Thomas Sheehan's experience, as related on page 630 of the September number, recalls what happened to me with two 150-horse-power horizontal tubular boilers, burning anthracite screenings with forced draft. We had to keep one fire over Sunday to hold the pressure for the blast. The boilers were connected over the top only, as shown in the sketch, the same pressure being used in each. Late one Sunday afternoon when there

was a slow fire under boiler No. 2, with two gages of water and about 50 pounds of steam showing, I opened the valve shown at *A*, to blow the mud out of the water column. A "rushing" sound set up inside of the boiler, and I shut the valve again quickly, but the noise continued for about a minute after the valve was closed. No steam was being used at the time, nor was the feed-pump running.



ILLUSTRATING MR. HAEUSSER'S LETTER

When the commotion ceased we found that the pressure had fallen from 50 to 30 pounds and water was running out of the whistle on top of the column of No. 1 boiler, while the whistle on No. 2 boiler was screeching for low water. A few minutes later we let the surplus water out of the blow-off, but nothing unusual occurred. What made the water go up a 5-inch pipe and down into the other boiler?

CHARLES HAEUSSER.

Albany, N. Y.

I never realized the far-reaching effect of POWER until I read pages 776 and 777 of the November number, which show that your paper is read more or less carefully in every corner of the western hemisphere. But, Mr. Editor, you brought all this criticism on me by not printing the sketch as I sent it in; that is, by neglecting to put in a valve on the steam connection, as I had it in my original.

I know it is not good for the boiler, nor is it economical, to leave boilers, with the fire drawn, connected with boilers making steam, but according to engine-room etiquette, when the chief says, "Pull the fire and leave her stand without cutting out," why that's the way they are left, without any comment from the assistant. I do not think it is necessary for me to write my article over again, just because some people did not read it correctly.

THOMAS SHEEHAN.

Pittsfield, Mass.

[Mr. Sheehan is right in accusing us of misrepresenting his sketch. In the original there was a valve in the steam connection, as he states, but our artist added the steam main and put the valve in it. —EDITORS.]

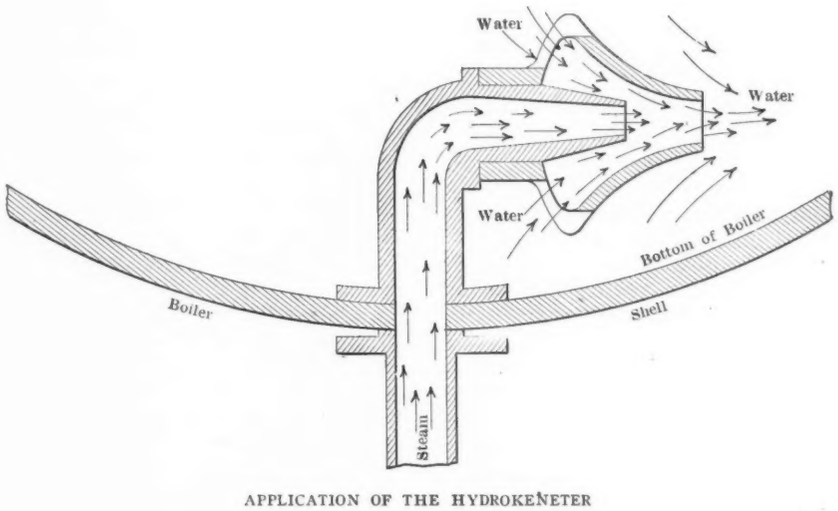
If fires are drawn from a boiler and the blow-down valve is opened without the boiler being in communication with other boilers, the boiler will empty without injury, except that the steam which flows in from the other boilers will be hot and dry and will bake scale onto the sheets and tubes which otherwise might be easily washed out or removed. Of course with externally fired boilers there is always the hot setting to be considered.

In reply to "Inquirer," who wrote on the same subject on page 777, I would say that there is an appliance used to warm and circulate the water in a boiler while raising steam. It is called an hydrokeneter and, I think, was invented by James Weir, of Glasgow, Scotland.

In an internally fired marine boiler of the Scotch type considerable water lies dead below the line of grates until circulation has been established by drawing out steam. I have often seen full working pressure on a boiler while the bottom of the boiler was as cold to the touch as when first filled, in cases where neither hydrokeneter nor pump was used to circulate the water while raising steam. It is customary to start the hydrokeneter, or a pump, piped to take water from the bottom of the boiler and discharge through the feed line, and keep them going until the gage stands at 15 or 20 pounds. By such means strains due to unequal expansion are avoided and the fires can be forced more in raising steam than would be the case otherwise. The accompanying sketch shows the hydrokeneter in its simplest form as applied to a marine boiler; the combining tube is fastened to the nozzle by a four-armed spider, thus allowing free access of water at the rear end of the combining tube.

In the hydrokeneters now on the market the first combining tube discharges into a second tube having openings around the rear end, thus in a sense making it a compound instrument and, of course, adding somewhat to its efficiency; but for all practical purposes, where the main object is to add heat to the water by discharging steam into it from another boiler, the single instrument will do equally as well and will usually give ample circulation in the comparatively small boilers used in stationary practice.

In starting a hydrokeneter care must be taken to open the valve gradually until circulation has been established, when as much or as little steam as desired may be used. If the valve is opened too rapidly the recoil is very severe and may tear the fitting loose inside the boiler.



APPLICATION OF THE HYDROKENETER

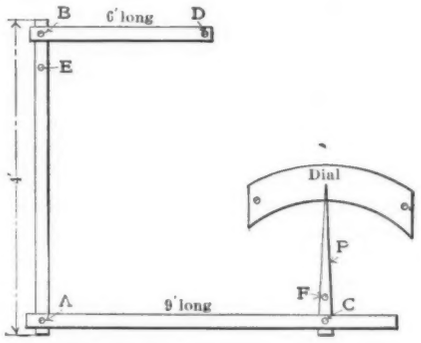
In a stationary boiler the hydrokeneter could be piped through the front head to one side of the hand-hole and discharge along the lower part of the boiler in a lengthwise direction.

A. T. ROWE.

Brooklyn, N. Y.

"A Home-made Thermometer"

The home-made thermometer shown by A. Heaton, on page 755 of the November number, reminds me of a much simpler one which I saw a few years ago. The accompanying sketch will give an idea of it. It is made of metal strips about one-half inch wide. Any lengths other than those marked can be used, if desired. The dial will have to be marked from a mercury thermometer. Referring to my sketch, *P* is the pointer; *A*, *B* and *C* are connected so that the joints will move freely; *D*, *E* and *F* are screw-nails inserted in the wall, but allowed to move freely in the holes in the strips. As the metal expands and contracts, the pointer will move up or down over the dial. If it is desired to have the pointer move up as the temperature rises,



MR. BEECHER'S HOME-MADE THERMOMETER

the dial will have to be at the top and the four-foot piece at the bottom.

HAROLD BEECHER.

Toronto, Can.

A Simple Problem in Transformer-coil Connection

Two transformers, each containing a single primary and a single secondary coil, are to be used for testing purposes with single-phase current. According to the nature of the demand for current and voltage, it is necessary to use the transformers either separately or together. The secondary windings of both transformers are designed for 110 volts. With reference to the external circuit it is necessary to obtain 110 volts from either transformer, or both must deliver 110 volts working in parallel. The third connection must be made so as to deliver 220 volts to the external circuit, using, of course, both transformers.

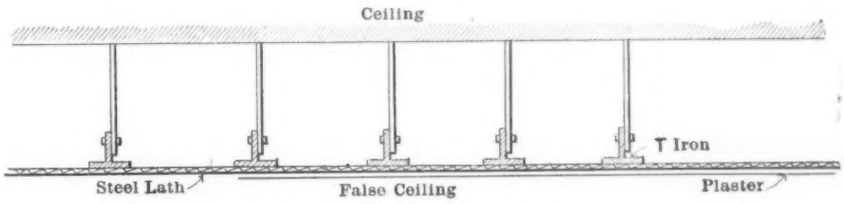
In other words, the connections must allow the use of either transformer separately, or of both together operating in parallel at the secondary terminals, or of both together operating in series at the secondary terminals. The problem is to make the connections by using only two commercial-type knife-blade switches, and these must be single-pole. The connections must be so arranged that a short-circuit will be impossible and the external circuit may be disconnected from the transformers when not in use.

E. S. LINCOLN.

Boston, Mass.

Suggestion for an Engine-room Ceiling

John Carroll, on page 775 of the November number, asks for suggestions for a ceiling for his engine room. As it is evidently desired to insulate the concrete roof from the heat in the engine room the accompanying suggestion may answer.



MR. CEDERBLOM'S SUGGESTION FOR AN ENGINE-ROOM CEILING

In a private plant in the basement of an apartment building the heat from the boiler room made the floors in the apartments directly above uncomfortably hot, and to overcome this trouble a false ceiling was put up, as shown in the sketch. Light T-irons were suspended about five inches from the original ceiling, two feet apart. To these were fastened steel laths plastered in the usual way. It made a very nice, smooth ceiling and proved such a perfect heat insulator that a few small openings connecting the space between the two ceilings with the outside air had to be closed up on first approach of the cold season, as several small water pipes running up through the ceilings were found to be frozen solid.

R. CEDERBLOM.

Chicago, Ill.

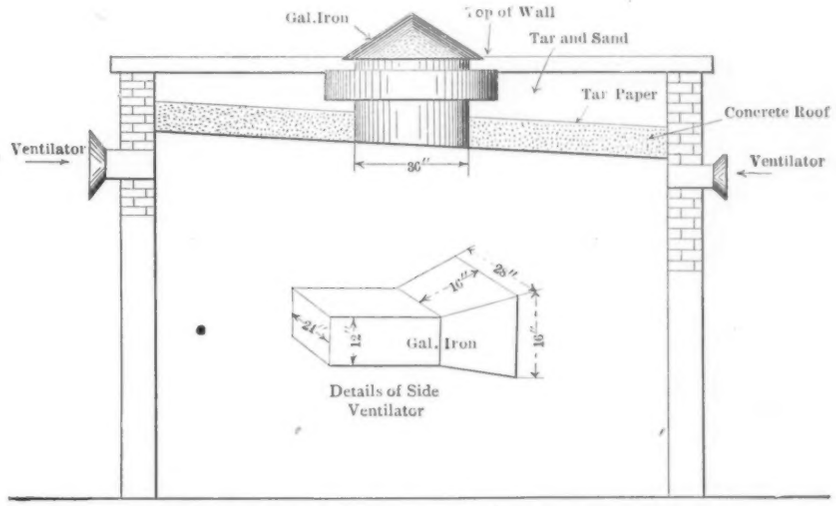
If the cross-beams supporting the engine-room roof are not an excessive distance apart I should suggest the use of expanded metal lathing and a cement plaster to form the ceiling. If the roof timbers are a considerable distance apart, enough light framework can be framed in between these timbers to support the metal lathing. Any good cement plaster will serve the purpose.

I should suggest, however, that the best means of overcoming this dampness would not be by means of a ceiling but by improving the ventilation in this portion of the factory and thereby removing the cause of the dampness. With a plentiful supply of air coming from near the ceiling outdoors there is no occasion for dampness of this character to accumulate.

HENRY D. JACKSON.

Boston, Mass.

The accompanying sketch is self-explanatory. It is an arrangement which, I feel confident, will prevent the dripping from the ceiling that Mr. Carroll complained of. I have "cured" several ceilings by the same means. The side ventilators should be not farther apart than 30 feet from center to center all around the side walls.



MR. MERRELL'S PLAN FOR VENTILATING ENGINE ROOM

MANLEY J. MERRELL.

St. Louis, Mo.

POWER

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Are You Ready?

There are crises in the life of every man when some incident, trivial in itself, occurs to change the whole course and tenor of his existence. An engine breaks down and you go to the builders for renewals and repairs. On the train you meet a gentleman who learns your errand, learns that you are an engineer and a good one. He is a man of affairs, has industrial interests, talks with you of problems with which he is engaged, takes your card, and months afterward you may receive a call which will change the scene and field of your activities, open to you new opportunities, impose upon you new responsibilities, and change completely your environment and manner of life—because an attendant was careless, because a boiler primed, because a man in setting up a nut gave the wrench one tap too much or too little, because you took that especial train, because he was on it and some little circumstance led him to speak to you or you to him, because, more than all, you were able to impress him that you knew your business. The idea is that the merest trifle of a circumstance produces so far-reaching a result. A pebble in the way of a drop of rain may determine whether it will flow to the east or to the west and mingle with the Atlantic or the Pacific.

This is as true of nations as of men, of the race as of the individual, and in the history and development of the human race there stand out two such little incidents: Gutenberg stamping his intaglios on a piece of vellum, and Watt watching the cloud of steam arising from the boiling kettle.

Nations have arisen and fallen, kings have been made and unmade, great physical upheavals have buried cities and changed the face of the planet, but what has been the effect of any or of all of these upon the development of the human race compared with the effect of the invention of the printing press and the steam engine?

All the world stood agape to know who would win at Waterloo, but not a score of people knew or cared whether Gutenberg's idea of printing with movable type was practicable or not. Who could have foreseen the tremendous import of the invention of printing upon the development of man? The only means for the transmission of human thought and the record of human achievement was by oral tradition, or the laboriously written works of the scribes. Few could read. What was the use? There was nothing to read. Take reading out of your life today and where would you be? Take reading out of the life of the nation and what would become of us? How far would the race have gotten if each generation had had to take up the battle of life anew with no record of past attainment, with no common means for the interchange of thought, for the dissemmination of knowledge, for making the creations of inspiration and of talent, the results of study and research and the achievements of industrious ingenuity the property of the whole people? Who indeed could have predicted the civilizing potency, the far-reaching results, of the successful printing of that first book in the middle of the fifteenth century?

And now, if this simple illustration has placed you in the right mental attitude, consider how absolutely impossible it was for the contemporaries of Watt to justly estimate or foresee the important effects of his improvements in the steam engine. To the average man the statement that the history of steam engineering is practically contemporaneous with that of the American Republic comes with startling significance, so much has mankind learned to depend upon it in so short a time. Mentally trace the curve of its development from its small beginnings in the last quarter of the eighteenth century; follow it as it was known to the older engineers of today in the years of their first activity; follow its sharp ascent during the past quarter century; follow its rising course into the century to come, and you will see that its opportunities are as boundless, its possibilities as undreamed of as were those of the art of printing at the end of its first century of existence.

Are you ready to meet them?

The Man Behind the Scoop

The place in a steam plant where money is saved or lost in daily operation is in front of the boilers. The plant may be well or illy designed; the piping may be direct, tight and well-covered; or it may be crooked, leaky and bare; the engines may be tight and correctly set, or leaky or out of adjustment; but taking a plant as it is, the greatest variable in its efficiency is the man behind the scoop.

The owner puts in an expensive economizer to save the last few heat units, and the fireman puts so much air through and reduces the temperature of the flue gases to such an extent that the economizer has little or nothing on which to work.

The owner gains twelve or fifteen per cent. by putting in compound engines, and the fireman loses twenty or twenty-five per cent. through imperfect combustion and careless handling of the feed-water.

The position of a fireman has come to be of the utmost importance. A man who knows how to burn coal so as to get the most heat out of it, how to manage his boilers so as to get the most of that heat into the steam, and how to deal with the problems of feed-water, scale and furnace construction, can go into any boiler room and exert a greater influence on the efficiency of the plant than the man in the engine room can do, no matter how competent the latter may be.

A "Penny Wise and Pound Foolish" Policy

The penalty of short-sightedness is cumulative. The loss in efficiency which results from the exercise of false economy in the purchase of equipment continues to roll up year by year, as long as the conditions are maintained. A hesitating policy, unwillingness to spend when imperatively necessary and delays for want of absolute decision conduce to an increase in this loss. Self-evident as are these facts, they do not serve to prevent examples on every hand of a "penny wise and pound foolish" policy. Such is presented by the following story of strangely consistent inconsistencies, of losses linked together like the characters in the "House that Jack Built," each in a way dependent upon the other.

In the process of building a large manufacturing plant, it became necessary to provide power and heat for one part long before they were required for the rest. There were logical and economical reasons why the main power plant could not be completed in time to meet the requirements. So a very effective temporary plant was installed. A second-hand locomotive boiler was equipped with mechanical induced-draft and a short stack. Independent engines belted to generators were well located upon temporary foundations. The extra expense entailed above that which would have been necessary to get the main plant into operation at an earlier date was not great. In fact the entire arrangement appeared satisfactory, and withal possessed some novelty. With this equipment a portion of the plant was well served during the succeeding winter. But spring came, and summer passed, before the temporary plant with its necessarily inefficient equipment could be abandoned and the large plant put into operation.

The reason was simple, but its effect disastrous. Bids for the permanent boiler equipment were secured in ample time to have insured its being in operation before the rest of the plant required power. But because there appeared to be a possibility of forcing down the price the entire proposition was held up for a couple of months. When the deal was finally closed, the reduction in price amounted to less than five per cent. of the first bid. Even this small concession might have been as easily secured in the beginning, if the matter had been intelligently approached.

In the meantime the temporary plant was taxed to the breaking point. Clear Pocahontas coal was of necessity burned to produce the requisite steam. The boiler was seriously strained and barely could be kept in service until relief came, and it was finally sold for scrap, whereas it might have brought a fair price had it been in working condition. The engines, running to maximum cut-off, were prolific users of steam, and the source of constant trouble because of excessive wear under the overload. Considerable expense was afterward incurred in putting them into operative condition.

When at last the permanent boilers were ready for steam, the large generating set which was to form part of the equipment was still in process of completion. But short days were at hand; more light as well as more power were required. Several relatively small engines with belted generators were therefore installed on a testing plate near the heart of the plant, some eight hundred feet from the power house. The connecting steam pipe was inadequate to carry full pressure for maximum load. For a time the heat loss was excessive because of piping still remaining uncovered, and the condenser installed with the equipment at the power house was not available for use in connection with the engines more than an eighth of a mile away. The small, relatively inefficient engines were therefore run non-condensing, the shop was closed down early to avoid the excessive overload due to lighting, while the utmost caution was demanded to prevent power failure at the foundry cupola.

So the winter was passed. It was fully demonstrated that an extra boiler which the management had previously refused to install would have to be put in during the summer. This was done at a cost obviously far in excess of what would have been necessary had it been made a part of the original equipment.

The second winter passed with the main unit established in the power house, and under ordinary conditions running condensing. But in the meantime tools and equipment had been increased, more power was demanded, and as a natural consequence a portion of the temporary equipment became almost permanent in its operation at a point distant from the main engine. No steps were immediately taken, however, to provide additional equipment at the power house; a third winter therefore passed under the prevailing inefficient conditions, and finally about three years after the main plant had been put in operation, it was made practically complete.

In the meantime there had been constant excessive loss through many channels. The highest-priced coal had been used; the engines had run under exceedingly inefficient conditions; the value of the condenser had not been utilized; extra help had been required to watch and maintain independent plants; there had been losses in the transmission of steam and in stoppages from lack of power or light; and the rate of work had been decreased through lack of interest. The cumulative total was outside the realms of calculation. It was the natural result of a hand-to-mouth policy, of "saving at the spigot only to waste at the bunghole," of niggardliness and delay in providing the equipment, and of extravagance and long continuance in all that made for inefficiency. It was an example of the persistency of human nature, rather than evidence of inferior engineering ability, and an example that ought to teach a lesson not soon forgotten.

Use of Standard Stud-bolts

A correspondent, who has been put to a great deal of trouble from their failure to do so, requests us to urge manufacturers to use standard threads on bolted work. This applies especially to stud-bolts, cap-screws and the like. If the bolt goes through and has a nut upon it, uniformity is not of so much importance. The adoption of arbitrary sizes to suit the whim of an over-specialized designer, or to compel the customer to return to the shopfo r small repairs, entails an unnecessary hardship upon the owner and user, and puts the machine at a disadvantage as compared with one in which standard bolts and fittings are used which may count for more in competition than the advantages sought to be gained by oddity.

A Caution Justified

Some months ago we advised small investors against being duped by the exploiters of marvelous mechanical inventions which, according to the half- and full-page advertisements in the Sunday papers, are destined to revolutionize steam engineering and make the fortunes of their shareholders.

One of the things which we had in mind was the "cold motor" exploited by one Benson Bidwell, who claimed to be the inventor of the trolley-car system, the railway-car telephone system, and pretty much everything else except Niagara Falls.

It is no surprise to learn from the Chicago *Tribune* that Mr. Bidwell and his son have been indicted on charges of embezzlement. The attorney for the stockholders says that the Bidwells have collected some $250,000 through their stock-selling plans, $200,000 of which has been expended in advertising and the rest taken over to the personal account of the president, Bidwell, and the secretary, his son.

It turned out that a son-in-law of the president was superintendent of the factory and a director, and another director, announced as R. Howe, was the president's daughter.

About 4000 victims nurse their blighted hopes.

The Hamilton-Holzwarth Turbine

This is a turbine with a multitude of stationary blades and running wheels, one running wheel with one row of buckets always coöperating with one row of stationary blades in such a way that the steam flows in an axial direction between vanes arranged on a full circle of practically the same diameter, both in the stationary blade and in the running wheel. The steam on its passage through the turbine is compelled to accelerate its flow,

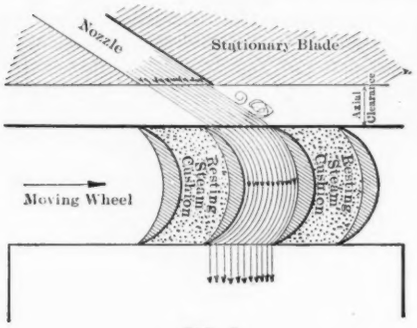


FIG. 1

when passing between the vanes of the stationary blades, and when traveling between the vanes of the next following running wheel it delivers the energy set free to the shaft in the form of deflection pressure upon the buckets of the running wheel. This process is repeated in the consecutive stages until the full expansion capacity of the steam is exhausted.

It will be evident from this short characterization that the Holzwarth turbine is a fully impinged action turbine with pure pressure stages, that it differs from the Parsons turbine in being an action turbine with a pure deflection action upon the buckets of the running wheels, that it differs from the Rateau turbine in being a fully impinged turbine clear through, and from the Curtis turbine in being a turbine with pure pressure stages, only one row of buckets in each running wheel taking care of the velocity of the steam flow.

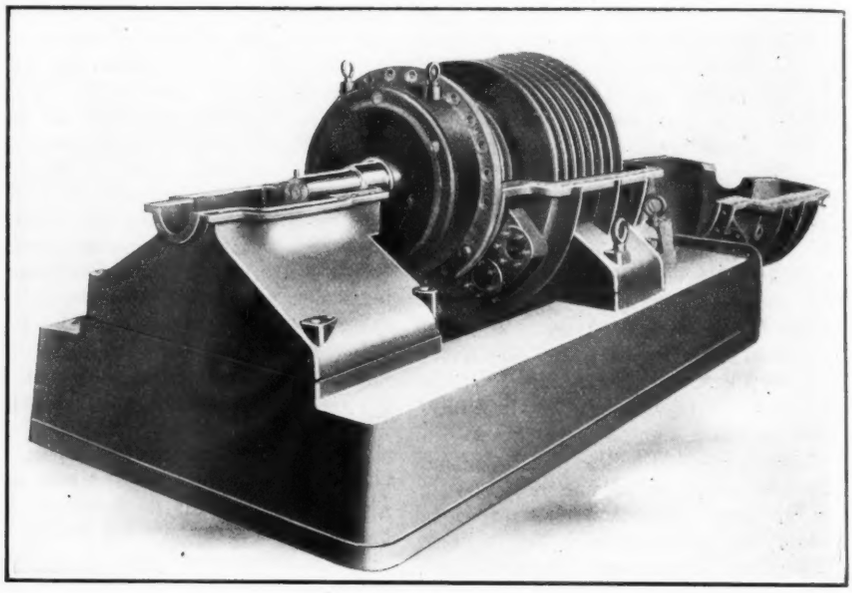


FIG. 3. HOLZWARTH TURBINE, WITH CASING REMOVED

In this connection it will be well to discuss the feature of full and partial impingement in steam turbines. The term "fully impinged" is applied to turbines in which the working fluid is delivered to the running wheel uniformly all around the circumference, while in "partially impinged" turbines the working fluid is de-

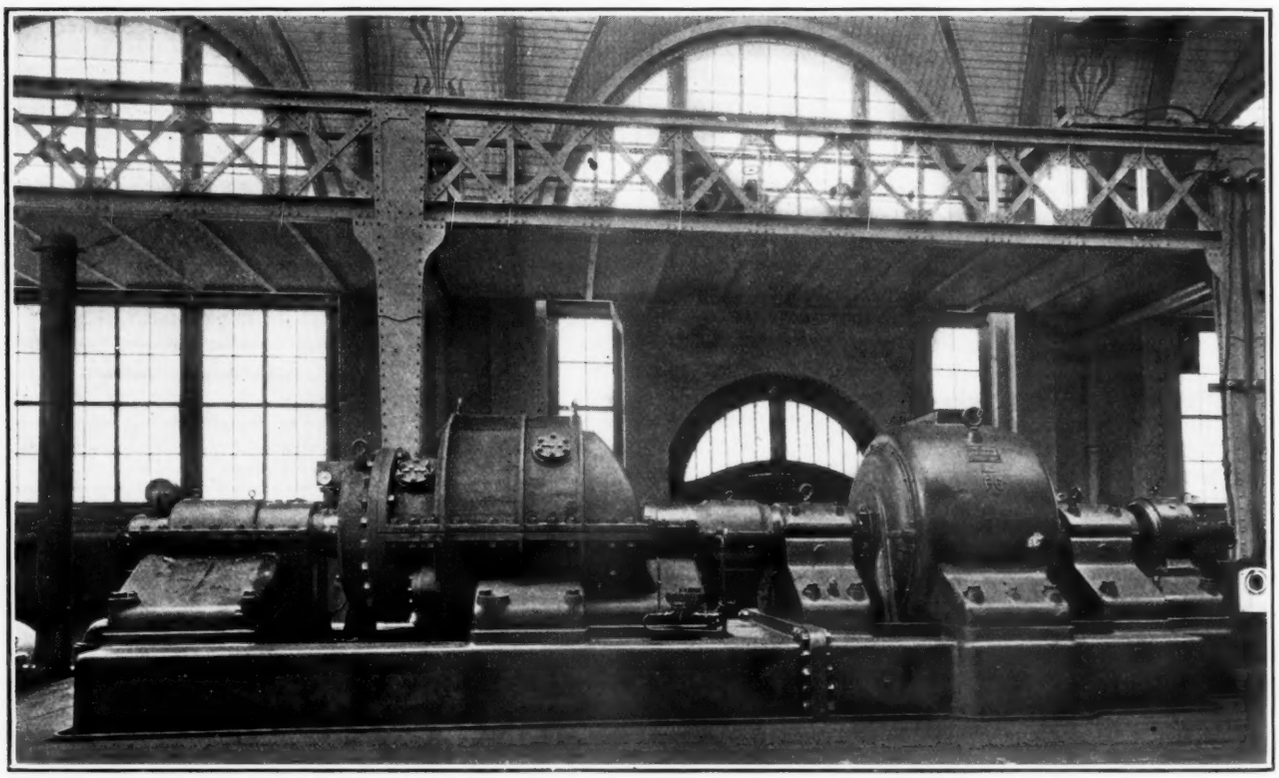


FIG. 2. 500-KW. HOLZWARTH TURBINE GENERATOR IN LABORATORY OF THE TECHNISCHE, HOCHSCHULE, DARMSTADT

livered only at a portion of the circumference.

In fully impinged turbines the working fluid is usually guided on its flow to the buckets of the running wheel by curved guide-vanes, the section of the chamber between the vanes being rectangular, while in partially impinged turbines the working fluid has to flow either through nozzles of circular or oval section, or between curved vanes forming guide channels of rectangular section arranged singly or in groups in one or several places upon the circumference. This characteristic applies as well to steam turbines as to water turbines.

Considering the fully impinged turbine, it will be evident that the steam when leaving the stationary vanes, forms a circular veil, intersected only by the thickness of the metal forming the vane. The steam, therefore, will impinge uniformly upon all of the buckets of the running wheel, keeping all of the channels between the buckets uniformly filled with flowing, and therefore working, steam. Considering one single channel between two consecutive buckets of a running wheel, there is a continuous flow of steam through this channel, while the wheel is rotating, and the buckets forming this channel continuously absorb energy from the steam, to compensate for the losses (windage, whirl, eddy, bearing- and skin-friction losses), and to deliver useful energy.

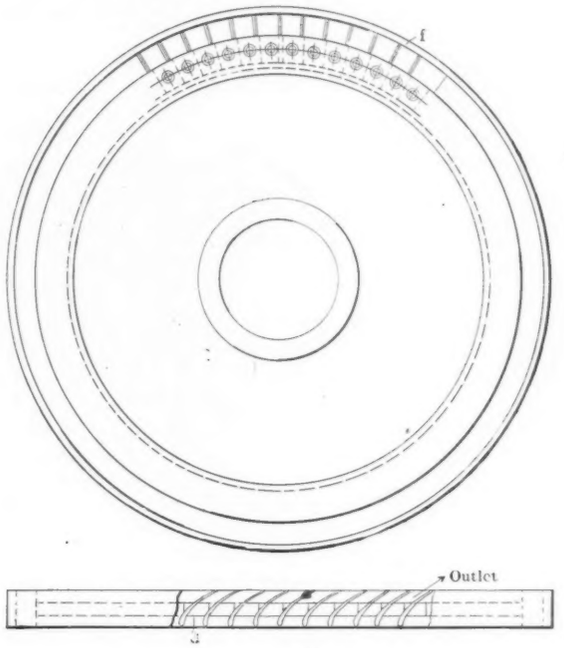


FIG. 4

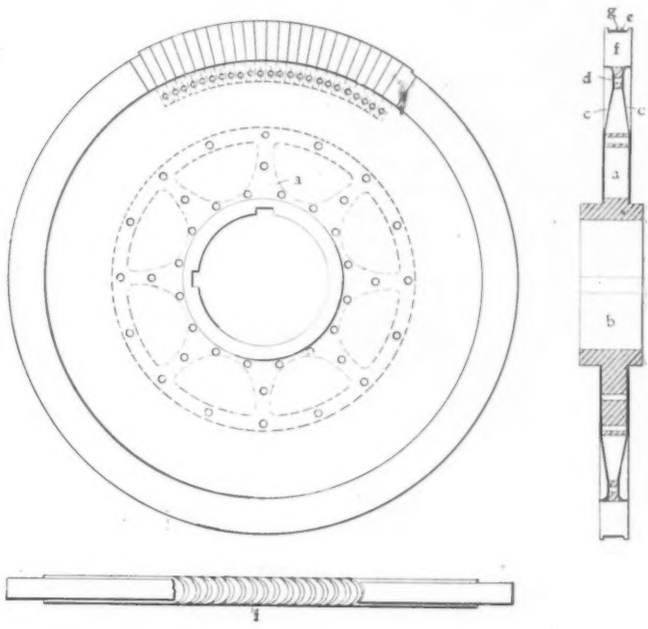


FIG. 5

In fully impinged turbines the buckets of the running wheel travel through a continuous veil of steam, which again travels in a direction tangential to the curve of the bucket, with reference to the inlet edges of the buckets, causing no whirls at these inlet edges and thereby materially reducing the windage due to these inlet edges of the buckets.

In *partially* impinged turbines the steam, when leaving the stationary vanes, forms one or several distinctly separated jets, thus impinging only upon a certain part of the traveling buckets, which alone contribute to deliver useful energy and to compensate for the losses due to all the buckets.

Considering one channel between two consecutive buckets during one rotation, this channel will be passed through by working steam, when opposite to a nozzle. After leaving this position, there will remain a resting steam cushion until it comes again opposite to a nozzle. The steam jet from this nozzle has to push away the resting steam cushion before it can deliver useful energy by deflection. Although the mass of the steam cushion is very small, the impact means noticeable loss, as the velocity in partially impinged turbines is considerable. Besides, the buckets traveling partly through a steam jet, which again travels in a direction tangential to the curve of the bucket, with reference to the inlet edges of the buckets, and partly through a body of steam with no distinct motion of its own, will cause considerable whirl and eddy losses, especially in the latter places, and the windage losses due to the inlet edges of the buckets will be considerable there.

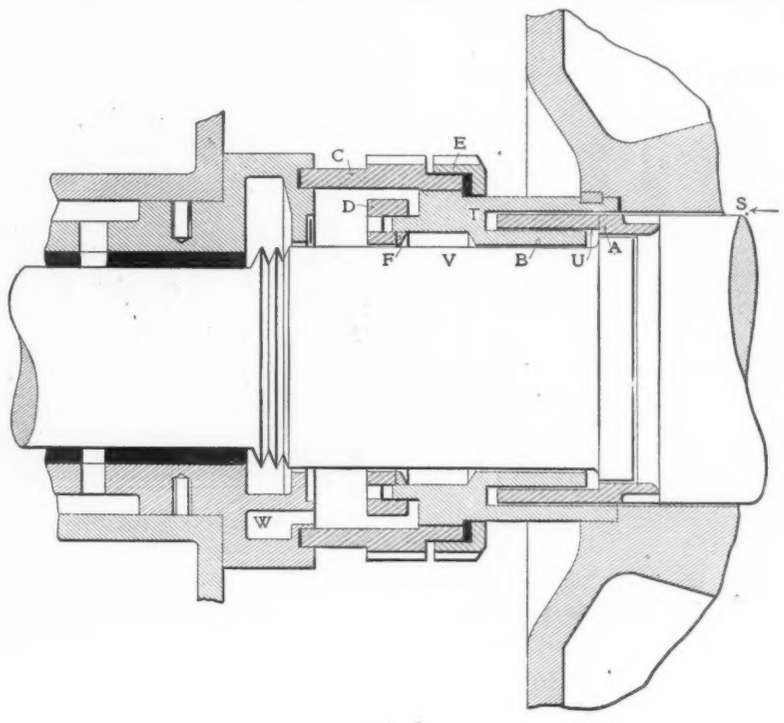


FIG. 6

It is evident that these losses depend on the axial clearance between the inlet edges of the buckets of the running wheels and the exit edges of the nozzles (Fig. 1); the larger the clearance the greater these losses. Partially impinged turbines, therefore, call for small axial clearances.

While the reaction turbines (Parsons) necessarily call for full impingement, the action turbines, with equal steam pressure on both sides of the buckets of the running wheel, can be built with either full or partial impingement, or both. On the other hand, the reaction type, with different steam pressure on both sides of the buckets of the running wheel, calls for small radial clearance between the outer edge of the buckets and the casing; while in action turbines this radial clearance can be made much larger without causing leakage losses, as long as the radial length of the bucket is large enough to intercept all the steam that has to pass through. Therefore, a fully impinged action turbine with pure pressure stages can be built with considerable axial and radial clearances, without sacrifices in economy.

The Holzwarth turbine is the first turbine of this type and the results of a test, as shown in the diagrams herewith, will show that these considerable radial and axial clearances do not cause any extraordinary losses.

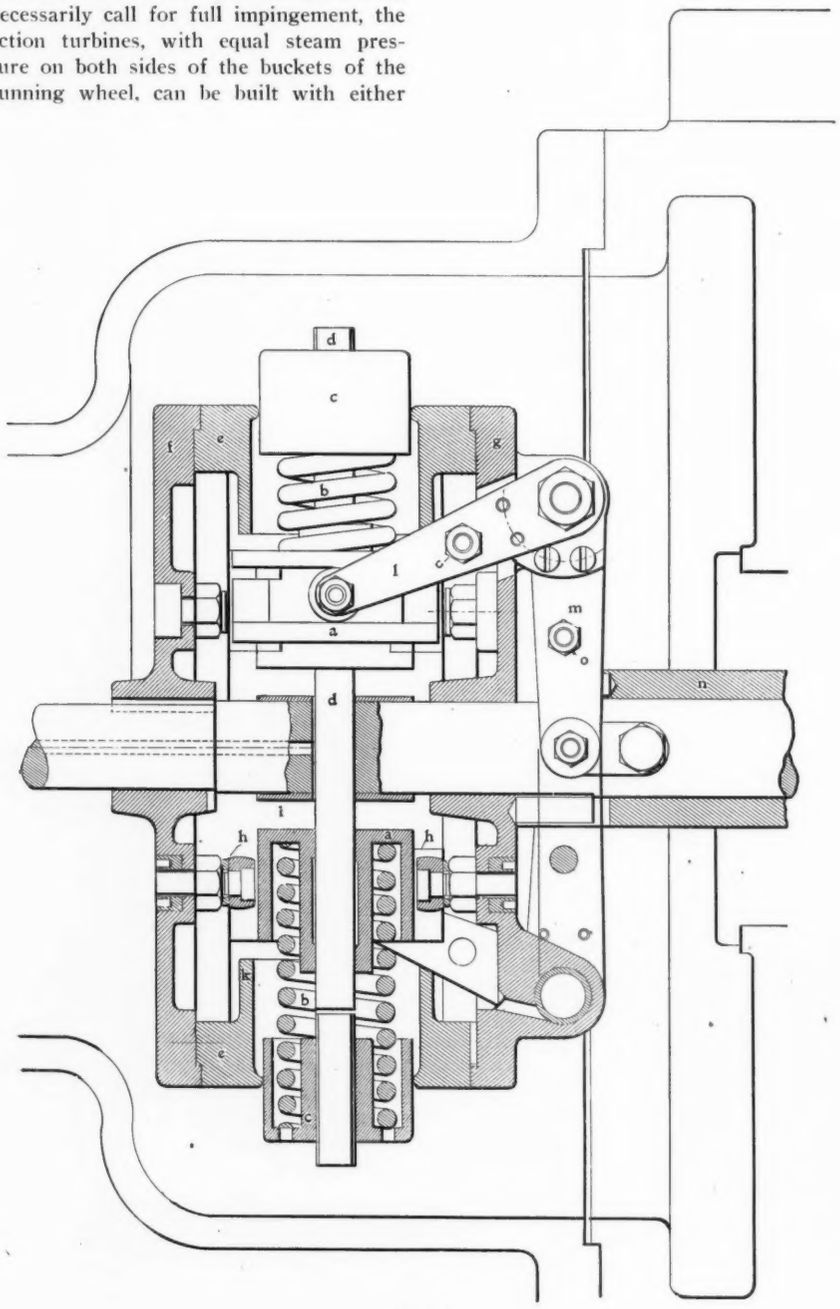


FIG. 7

Mechanical Features

Fig. 2 shows a 500-kilowatt turbine on the test floor of the laboratory of the Technische Hochschule, at Darmstadt, Germany. Fig. 3 shows the same turbine open. From these views it will be seen that all the stages of the turbine are assembled in one casing. The shaft carrying the running wheel is supported in two journal bearings. One, the low-pressure, is bolted to the turbine casing, while the high-pressure journal bearing is bolted to the bed-plate, with the governor housing fastened to it. The casing is closed on the high-pressure side by the front head, which receives the live steam from the regulating valve fastened thereto.

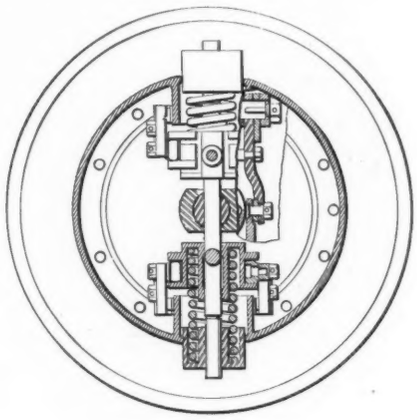


FIG. 8

On the step-up from the high-pressure to the low-pressure part can be seen the pockets for bypass steam for overload. The bypass valve, located underneath the regulating valve and controlled by the governor, admits live steam to these pockets for overload, and from these pockets the bypass steam flows through nozzles to the low-pressure turbine.

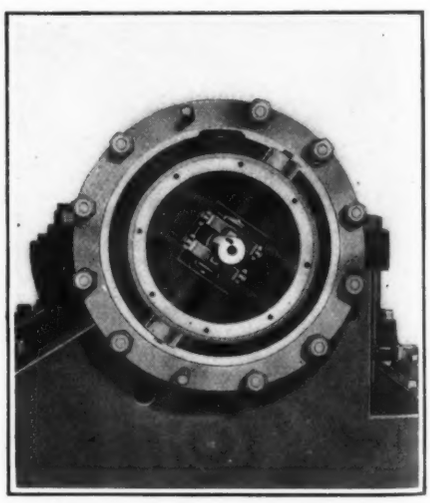


FIG. 9. GOVERNOR FOR 1800 R.P.M.

The casing is bolted to the bed-plate at the low-pressure end, and the shaft is also axially supported in the thrust-bearing located between the low-pressure journal bearing and the flexible coupling. Thus both the casing and the shaft expand in the same direction.

The governor, of the weight-spring type, is directly but loosely coupled with the main shaft. The governor shaft is supported in the two extra bearings.

allowing the governor shaft and the main shaft to expand and the corresponding bearings to wear independently.

The journal bearings and thrust-bearings are lubricated by a continuous stream of oil from an independently driven oil pump. The oil flows back to a water-cooled tank.

Construction of the Stationary Blade

A stationary blade is constructed in the following manner: A circular cast-iron disk *a*, Fig. 4, has a bore *b* corresponding to the diameter of the shaft, with the necessary clearance. On the outer circumference of this disk there is cut a groove *c*. The stationary guides, consisting of a vane of proper curvature and the adjoining piece, are of drop-forged steel, milled on all sides of the adjoining piece which fits into the circular groove *c*. These vanes are arranged all around the circumference so that one adjoining piece touches another and they are held in place and fastened securely, by rivets *e*, to the disk. The outer circumference of these vanes is turned off to the right size, and then a steel ring *f* is shrunk over them. This shrunk ring projects into the grooves of the housing.

The Running Wheel

While in the stationary blade the weight is not of great importance, in the running wheel it is very essential to reduce the weight as much as possible. It will be readily understood that the lighter the running wheels are, the less the bearings will have to support, and therefore the shorter they may be constructed, and the better they will work. Furthermore, by keeping down the weight of the running wheel the shaft diameter is kept within small limits. This determines the bore of the stationary blade, and with that the circular space between the bore of the stationary blade and the shaft can be kept within small limits; therefore in the construction of this running wheel every dead and unnecessary weight is avoided.

The running wheel is made up as follows: A steel hub or spider *a*, Fig. 5, has a bore *b* fitting closely to the shaft diameter. On both sides of the hub are riveted steel disks *c*. The groove on the outer circumference of the steel disk is turned out and forms a receptacle for the running vanes. The running vane itself consists of the properly curved blade, with an adjoining piece made in one section of drop-forged steel. The adjoining piece is finished and fits closely into the grooves of the steel disk. The running vanes are held in place and rigidly connected to the steel disks by rivets *d*, so that the centrifugal force of each vane is taken up by a rivet and transmitted through the rivet to the steel disk. The outer edge *f* of the vane is turned off and thus provided with an annular groove forming a receptacle for the steel band *g*, which is tied all around the wheel. It is held in place and secured to the vanes by riveting over the projecting ends of the vanes. The ends of the band are brazed together.

A very important requirement of every high-speed machine is that all the revolving parts should be properly balanced so that no shock, vibration, nor the breaking of the shaft due to the centrifugal forces of unbalanced masses in the revolving part may occur. Therefore, each single running wheel is most carefully balanced in a special balancing machine, and each single wheel is tested with 100 per cent. overload by running it at the necessary higher speed.

All running wheels are secured to the shaft and held rigidly in place by a feather key extending through all the running wheels and by means of a nut screwed on the shaft and pressing all the running wheels tightly against the shoulder on the shaft.

The Stuffing-box

An effective means of packing a swiftly revolving shaft is a long sleeve surrounding the shaft with a very small radial clearance. The reason for this will be found in the throttling action of the steam particles revolving with the shaft. These steam particles have a tendency to fly outwardly and so prevent the steam from passing axially through the small clearance between the shaft and the sleeve. The reader will readily understand that it would not be practical to use such a long sleeve in the construction of a steam turbine, as this arrangement would considerably increase the length of the free shaft. For the reason that the deflection of the shaft depends upon the third power of the free length of the shaft, it is absolutely necessary to restrict this free length as much as possible.

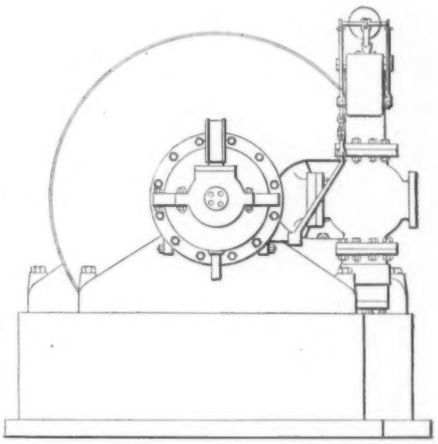


FIG. 11

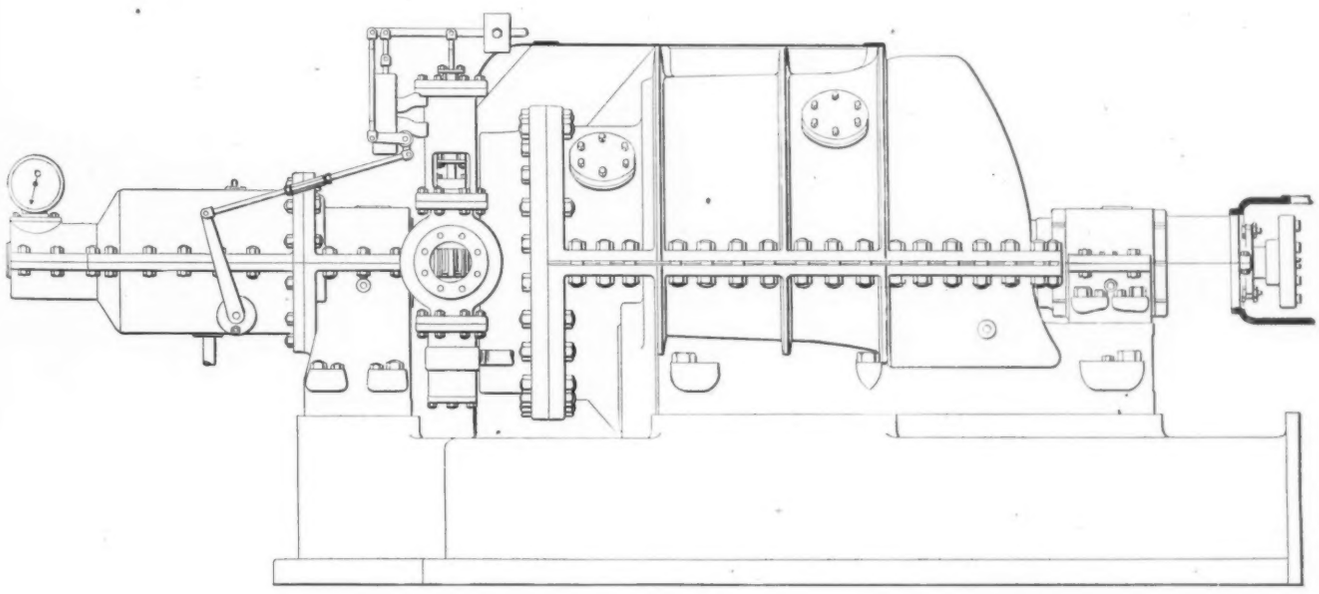


FIG. 10

In the Hamilton-Holzwarth steam turbine use is made of the telescope idea; that is, the entire length of the sleeve is split into several parts, and these single parts are shifted together. In Fig. 6 the ring *A* screwed upon the shaft projects axially into a groove of the ring *B* and revolves within it. The ring *B* does not move at all, but is held in place and pressed tightly against the turbine casing by means of the ring *C*, which presses against the bushing of the bearing. By screwing the ring *C* on the ring *B*, both rings are forced axially in opposite directions.

From the casing at *S* the steam seeking to escape flows axially to *T*; from there it flows back to *U*, and then forward to *V*, being very much throttled in the process. The ring *B* has an annular groove which must be packed with soft packing. Any accumulating water is collected in the chamber *W* in the bushing of the bearing, from which it is properly drained. The ring *E* serves only the purpose of tightening the threads between the rings *C* and *B*. When using the stuffing-box for the low-pressure bearing, where it must prevent the inward leakage of the air, the chamber *W* is filled with

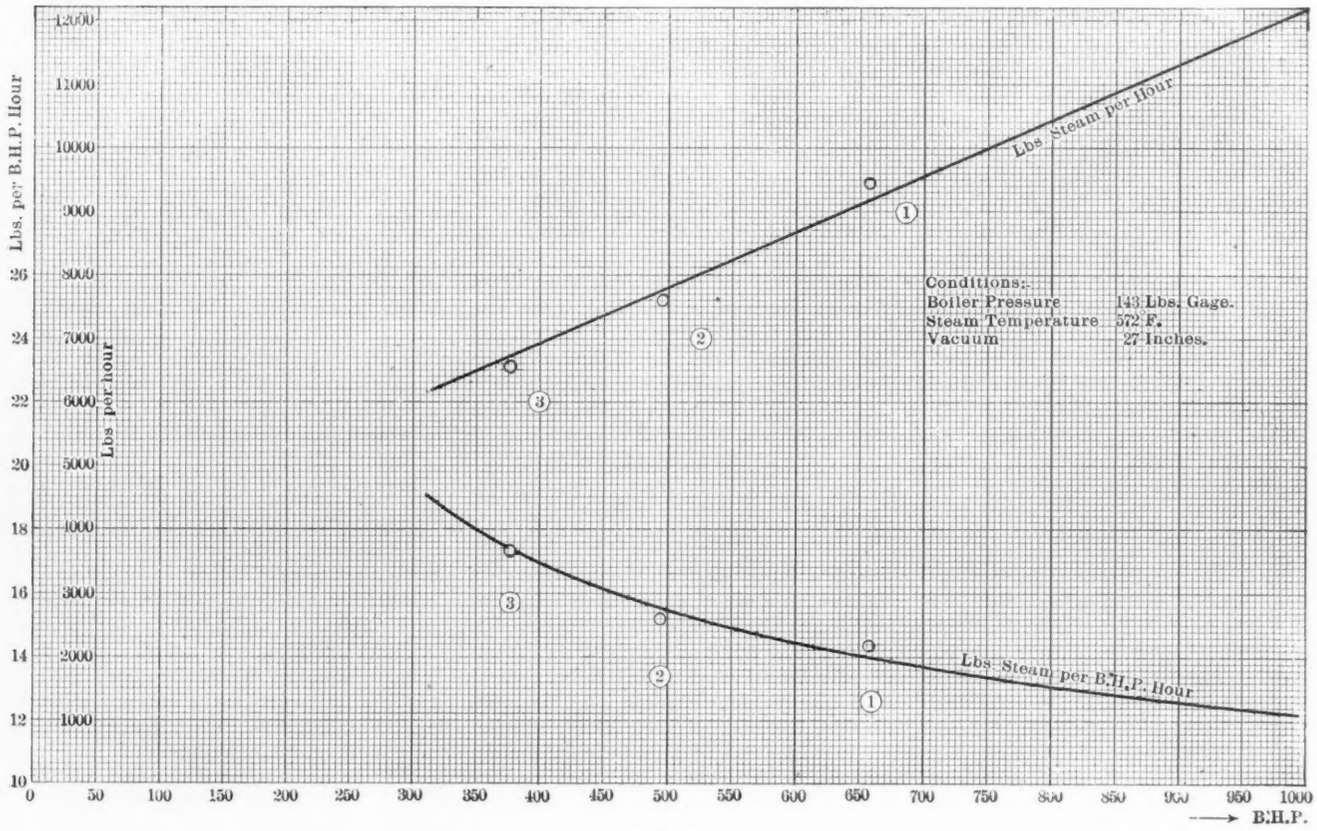


FIG. 12

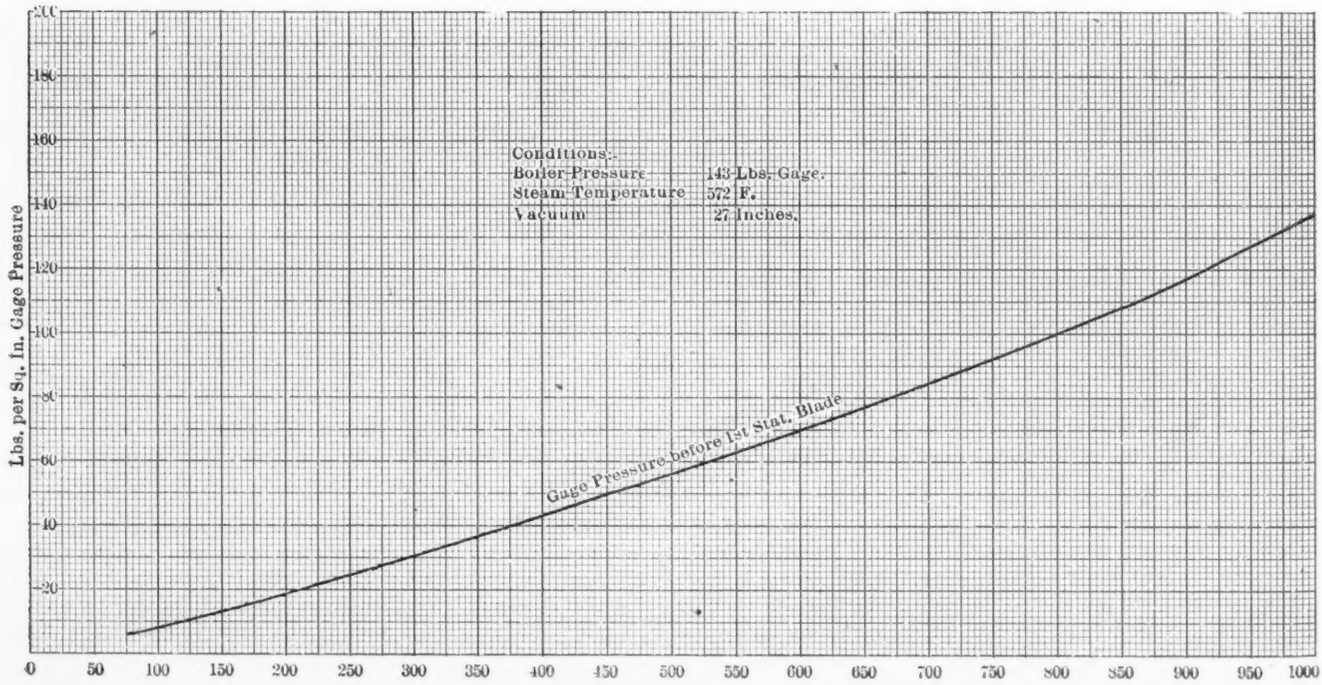

Lbs. per Sq. In. Gage Pressure
Conditions:
Boiler Pressure 143 Lbs. Gage.
Steam Temperature 572 F.
Vacuum 27 Inches.
Gage Pressure before 1st Stat. Blade

FIG. 13

water all the time, so that in case the stuffing-box should leak there would be no suction of air, but only water, which does not affect the vacuum.

The torque of the whole turbine is transmitted to the generator, or whatever the turbine may have to drive, by means of a flexible coupling, which permits the shafts to expand axially, independently, and in a slight degree to even move radially without affecting each other.

The Governor

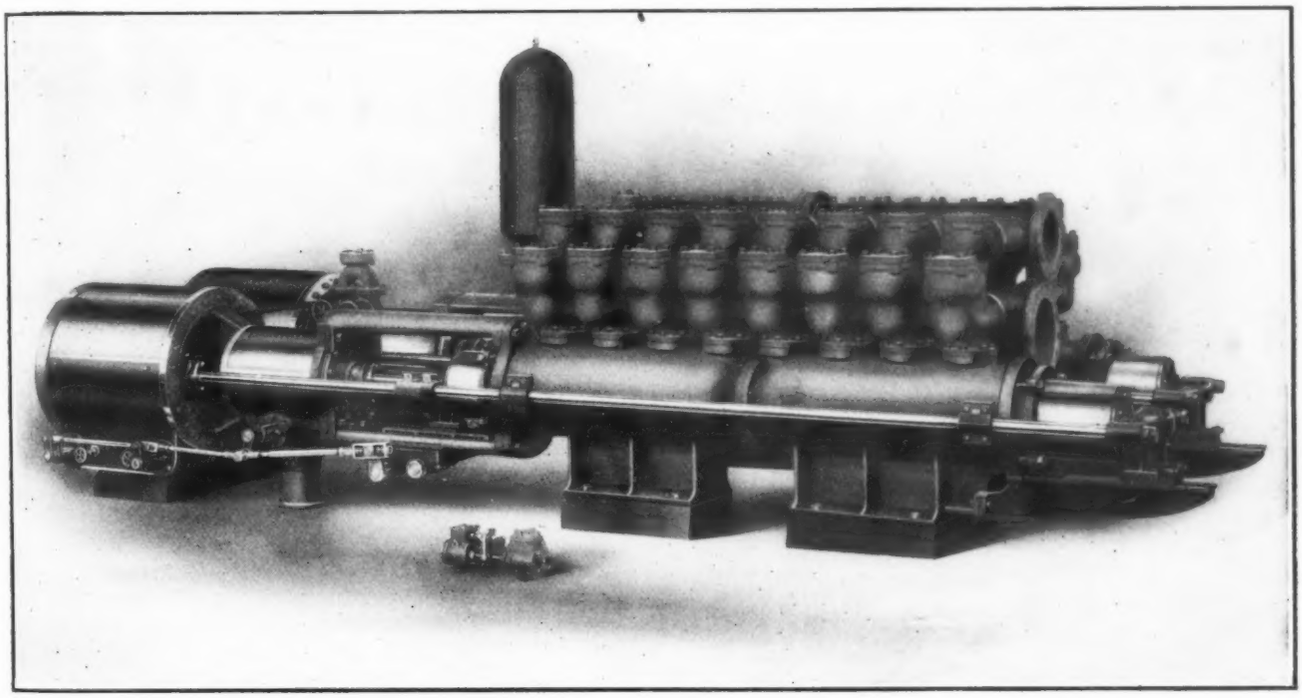
The governor shaft is directly coupled with the turbine shaft; that is, the governor runs with the same angular velocity as the turbine. The governor is of the weight-spring type, generally speaking, with special features essential to the high speed. The weights *a*, Figs. 7 and 8, on both sides of a cross bar running at right angles through the center of the governor shaft, have a tendency to fly outwardly because of the centrifugal forces; they are checked, however, in this movement by a spring *b* on each side, which is held in place by a nut *c* screwed upon the cross bar *d*. The nuts *c* slip inside the bore of a ring *e*, and this ring *e* is keyed on both sides to the governor covers *f* and *g*. These covers *f* and *g* are keyed to the governor shaft. The weight *a* is guided through rollers *h* screwed to the covers *f* and *g*, so that each angular acceleration of the governor shaft is transmitted to the weight *a*, not by means of the cross bar *d*, but by these rollers *h*. The rollers roll along the side flanges of the weight *a*. The movement of the weight *a* in the inside is checked by the rest *i* around the shaft, and on its outside by means of the flange *k* on the ring *e*. The movement of the weight *a* is transmitted by the levers *l* and *m* to the sleeve *n*. This sleeve revolves with the governor shaft and is engaged with the cover *g* and the sleeve *n*. This arrangement guarantees a positive coupling of the cover *g* and the sleeve *n* and it allows an axial movement of the sleeve *n* along the governor shaft with the least possible resistance. The levers *l* and *m* are arranged symmetrically on both sides of each of the weights *a*, and are provided with stiffening rods to prevent any deflection sidewise due to the centrifugal stresses. It will be readily understood that the levers *l* and *m* transmit only a fraction of the centrifugal force of the weight *a* according to the sensibility of the governor. The self-friction of the governor is reduced to a minimum, and therefore its sensibility is increased to a maximum. Fig. 9 shows a photograph of a governor for 1800 revolutions per minute.

The *regulating valve* is bolted directly to the front head, as shown in Figs. 10 and 11, or placed underneath the front head, as shown in Fig. 2. It is a double-seated poppet valve that throttles the total steam flow according to the load. It is actuated by an oil servomotor directly attached to it, as shown in Figs. 10 and 11. The governor controls through the floating lever a small piston valve which in turn admits oil under pressure to the servomotor. A change in speed can be arranged by shortening or lengthening the connecting-rod between the governor and the piston valve.

Figs. 12 and 13 show the results of tests made at the laboratory of the Technische Hochschule, Darmstadt, under the supervision of Geheimer Rat Professor Gutermuth, of that university. This turbine is built by the Felten & Guilteaume-Lahmeyerwerke, Frankfort - on - Main, Germany.

Large Boiler Feed-pump

The Fred. M. Prescott Steam Pump Company, of Milwaukee, Wis., recently shipped to the Ashley street power plant of the Union Electric Light and Power Company, of St. Louis, what is believed to be the largest boiler feed-pump in the world. This pump is of the duplex compound condensing type, having high-pressure steam cylinders 18 inches in diameter, low-pressure steam cylinders 34 inches in diameter and water plungers 17 inches in diameter, with 24-inch stroke in each instance. The normal capacity of the pump is 1800 gallons per minute, or 900,000 pounds of water per hour, which is equal to 45,000 kilowatts at 20 pounds per kilowatt-hour. The present capacity of the Ashley street power station is 36,000 kilowatts.



SIDE ELEVATION, SHOWING WATER END OF PRESCOTT PUMP

The novel departure of installing a boiler feed-pump in one large unit for this work will arouse the interest of engineers, because it is customary to install several small units for boiler-feed purposes in power plants of this size. But as a matter of fact, this large pump is the consummation of a process of evolution in this plant, which was at first equipped with several small feed-pumps. The earliest installation consisted of four vertical pumps, having a capacity of 600 gallons per minute each, it being the intention to operate two pumps at a time and hold

two in reserve, except on peak loads, when a third pump was to be cut in, leaving one in reserve. This worked well for a short time only. When the water valves and packing began to wear, two pumps would not do the work, on account of the combined losses through the water valves and packing. Then the third pump had to be run continuously to make up for these losses and slippages, leaving but one pump in reserve. It was soon discovered that two, sometimes three, pumps would go out of commission about as quickly as one, and it became a problem to keep the pumps in sufficiently good condition to carry the load.

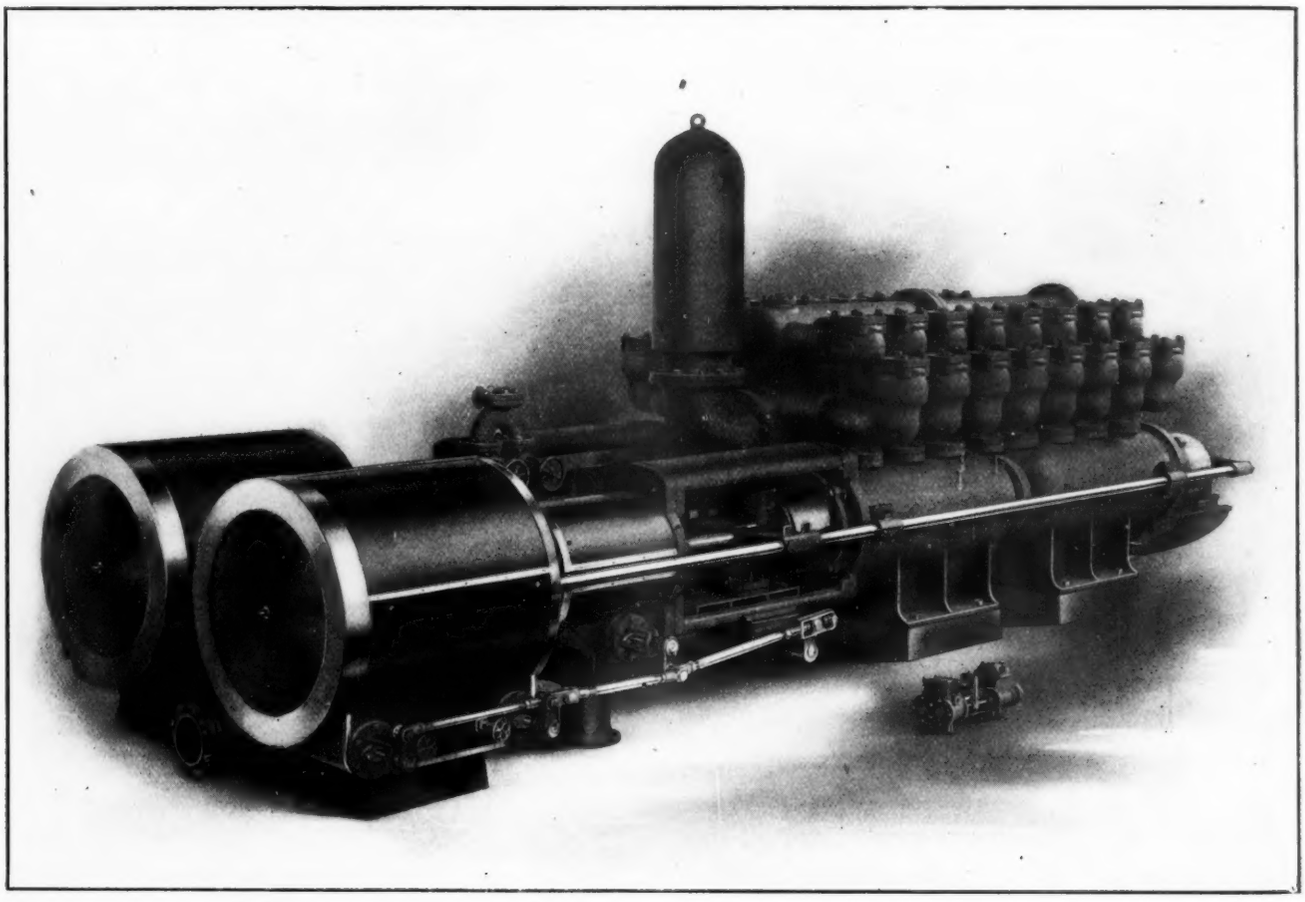
This state of things became so burdensome that two 24 and 14 by 24-inch simple duplex "pot-form" boiler feed-pumps, each with a capacity of 1200 gallons per minute, were installed. This reduced the number of boiler-feed units to two, each having double the capacity of one of the original 600-gallon units. This solved the difficulty at once. One of the new pumps would carry a much greater load than two of the smaller units; all of the parts of the two-unit pumps being much larger and stronger, the wear and tear and cost of repairs were reduced to comparatively nothing. The four small units were practically abandoned.

After about two years the load began to reach the capacity of one 1200-gallon pump, the increase rapidly approaching a point where both of the 1200-gallon pumps would have to run on the peak loads. Then the question of installing a third pump was taken up, but not a third 1200-gallon pump, for the management had learned that one unit was the most satisfactory basis of operation. It was decided to install a pump having 50 per cent. greater capacity than a 1200-gallon unit, and hold both of the 1200-gallon pumps in reserve.

The importance of economy was thoroughly discussed in connection with the proposed new installation. To run it non-condensing would mean a large amount of exhaust steam for which there would be no use, as the other auxiliaries furnished ample exhaust steam to heat the feed-water; so the pump herewith described was built to run compound condensing.

To produce the most economical results, the low-pressure cylinders and their heads are steam-jacketed; the steam valves are of the rotative type, there being one steam valve for the high-pressure cylinders and two each for the low-pressure cylinders. The arrangement of two steam valves in the low-pressure steam cylinders reduces the clearance to the lowest possible amount. The water end is of the the pot-form type, having four suction and discharge valves, 5¾ inches in diameter, in each quarter of the suction and discharge. The water plungers are of cast bronze of the outside end-packed type.

The boiler pressure carried is 175 pounds per square inch. The pump operates against a pressure of 225 pounds per square inch in the feed-water pipe system to the boilers. This feed-water system is provided with a relief valve, and the pump is controlled by a pressure governor. The boilers are provided with thermostat valves, which allow the water to flow into the boilers and maintain the proper level. All of the automatic apparatus may be controlled by hand, when desirable, for all the boilers or for each boiler separately. Such occasions are very rare, however, as the pump responds readily to changes in station load, and is under perfect control of the automatic devices for controlling and delivering the proper amount of feed-water to each boiler.



SHOWING STEAM END OF PRESCOTT BOILER FEED-PUMP

The feed-pipe system, in effect, is simply a system of water mains, in which the number of valves and fittings liable to leak are reduced to a minimum. The pump therefore becomes a water-works pumping engine, and if applied to water-works service in a European city it would supply 100,000 people, with a per capita consumption of 30 gallons per day or, in an American city, 50,000 people, with a per capita consumption of 60 gallons per day.

A boiler feed-pump of this size and type possesses a dignity which passes far beyond that of an ordinary boiler feed-pump. It requires no more attention from station employees than a smaller pump ought to have, all parts are much more accessible, and renewals and repairs are much more easy to make. The station employees realize they are handling a high-grade pumping engine, therefore it gets the care and attention it deserves, and not the scant attention usually bestowed on an ordinary boiler feed-pump.

The Ashley street power station is located on the banks of the Mississippi river, about one-half mile above the Eads bridge. The original building was located as closely as possible to the abutting street lines, and away from the river water line, because of the known existence of a large quicksand between the building and the river. When the present management decided to enlarge the building, the only direction in which it could be extended, because of the abutting street lines and railroad rights of way, was toward the river and through the bed of quicksand referred to. After taking out an enormous amount of water and sand a solid foundation was reached and a large addition to the building was constructed.

Eighty per cent. of the sulphur production of the world comes from Sicily.

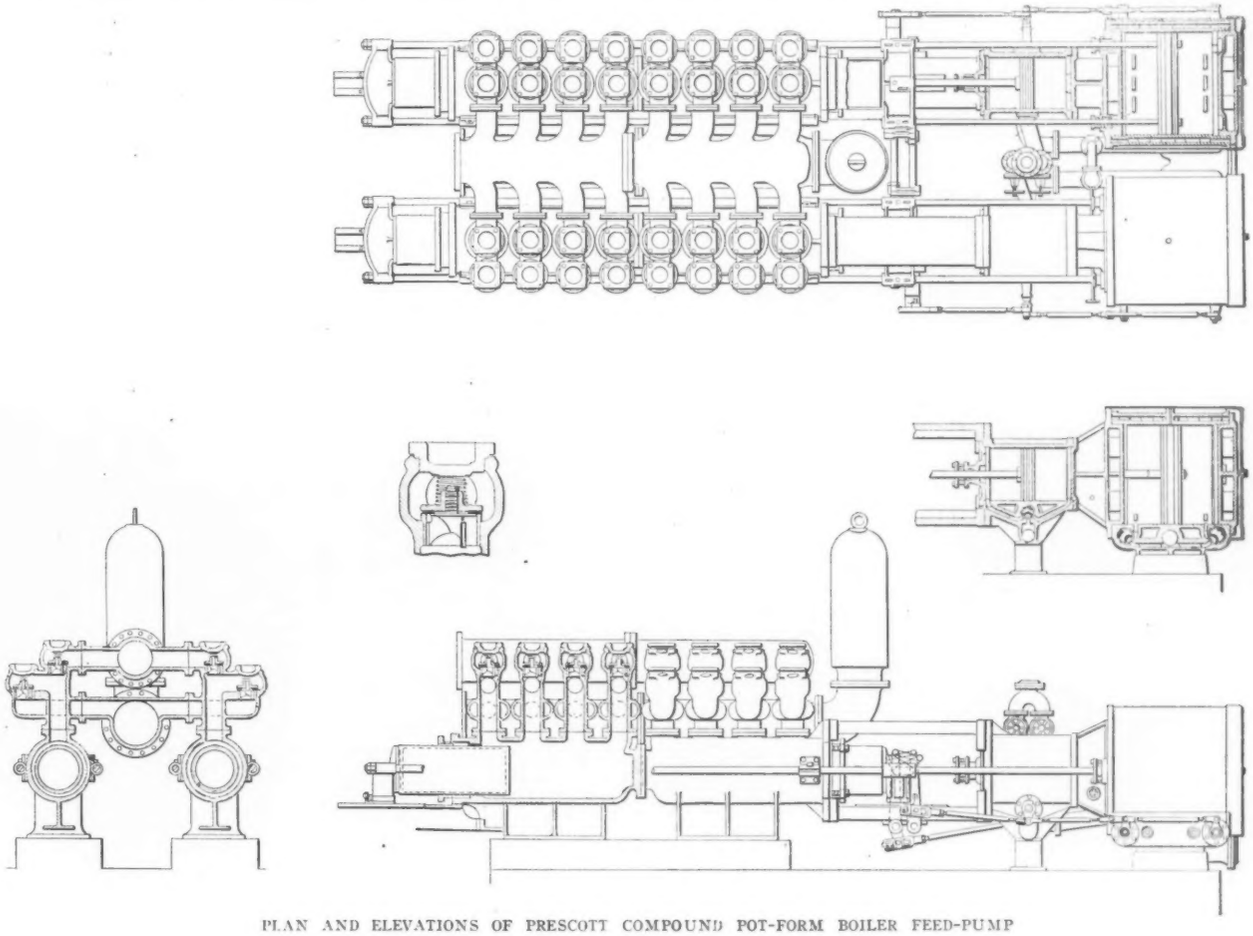
Carr Inclined Water-tube Boiler

Elmer E. Carr, whose address is New York Life building, Chicago, is the inventor and patentee of this boiler, which was designed primarily to eliminate the need of removing hand-hole plates in front and back of each tube for cleaning purposes, and to permit greater water circulating area through the connections from the tubes to the steam drum. The drums which serve as headers, into which the water tubes are expanded, are 30 inches in diameter, or large enough for a man to enter and handle a turbine cleaner. There are two of these drums, front and rear, connected by large cast-steel cylindrical saddles also of such size that the operator can pass bodily through the entire boiler, except the tubes, if necessary.

The headers are connected to the horizontal steam drum, which is 36 inches in diameter, by cast-steel flanged bends of proportionate dimensions. By designing both saddles and bends large, their carrying capacity is substantially equivalent to that of the tubes forming the main heating surface, having practically the same area. The inventor points out that the connecting nipples between the headers and steam drums of most boilers have to serve from nine to fourteen times their area in circulation, which explains the tube loss met with to a great extent; also, that ordinarily the design will not permit of enlarging these connections when building what are known as "double-deckers." With the Carr boiler, however, it is possible to enlarge the connections, so that a boiler three or even four drums high would seem to be practicable, there being five rows of tubes to each drum. Even if the connecting bends were not enlarged, the ratio would not be greater than two to one.

Mr. Carr ingeniously argues, also, that there is no reason why the drums cannot be made almost any length. The drums shown in the cut are of such length that the furnace width is 6 feet, giving a boiler horse-power of 183, based on 10 square feet of effective heating surface per horse-power. If the boiler were three drums high, with the same furnace width, 274 horse-power would be secured; if three drums high with a 12-foot furnace, 548 horse-power. From this there seems to be no reason why the distance between the furnace walls could not be increased to 24 feet, or even more, making a unit of 1100 boiler horse-power, or, increasing the hight by adding another drum, nearly 1500 horse-power. Then, if it is possible to force boilers in which the circulation is restricted to 50 or even 100 per cent. above rating, there is no reason why a capacity of 2200 or 3000 horse-power would not be possible with the Carr type.

These connecting bends are identical



PLAN AND ELEVATIONS OF PRESCOTT COMPOUND POT-FORM BOILER FEED-PUMP

both at front and rear, except that at the rear the upper or bent part is made longer to compensate for the difference in elevation of the drums.

The boiler front is made up of angle bars interspaced with expanded metal over which asbestos is plastered, making a light and non-conductive surface, with a space between it and the adjacent drum shells for the circulation of such hot gases as may radiate or be drawn into it from the combustion chamber.

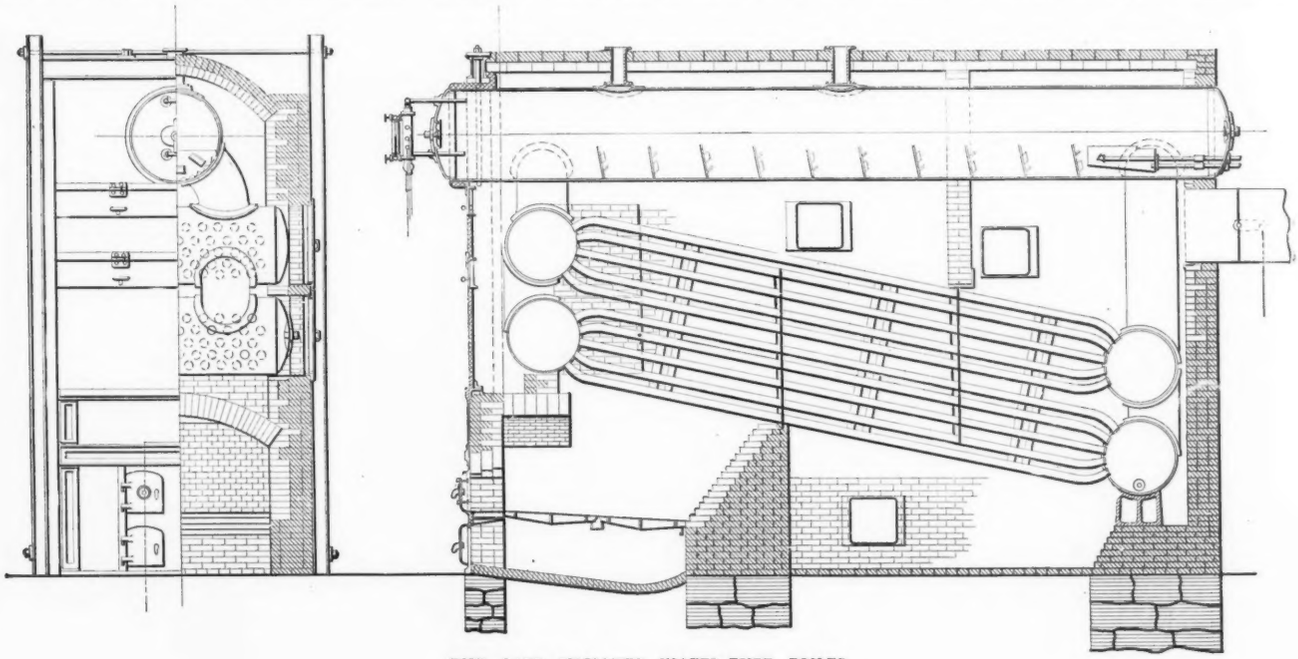
Doors are provided for the removal and replacement of tubes, which process is further facilitated by the provision of a space, between the center or straight tube and the adjacent tubes, of sufficient width to permit of a damaged tube being brought out diagonally over the top of the next lower row of tubes and removed through the door shown on the outside face of the wall covering the drum cavities. The inside face of the wall is battered sufficiently to permit the tube to clear the end of the drum. This relates to the three center rows of tubes in each drum only. A tube in the lower row can be taken out through the furnace door, or through a door under the lower drum. The top tubes of all the drums and the bottom tubes of the upper drum are removed through the space between the drums which is not taken up by saddle connections, and through the doors provided in the boiler front. A special form of baffling is provided, which is removable when it is necessary to get at the tubes. This baffling, however, is not confined to any special type of boiler. A flue-blowing door is set at right angles to the tubes. This feature is new and is said to reduce the labor of blowing the tubes to a minimum.

The boiler is shown resting in a saddle at the rear and hung in front, which permits freedom of expansion and contraction, although it can be hung at the rear, also, if desired. At the rear of the lower drum a perforated pipe runs the entire length, the perforations being on the bottom side of the pipe only and so graduated that when the blow-off is open the sediment which collects in the bottom of the drum is evenly discharged from its entire length.

Another special feature is in the roof or covering over the steam drum, allowing a space of 6 inches between the drum shell and roof for the circulation of the gases, not a path for the gases to discharge through, but a dead-end for radiation from the gases in their travel from the first pass to the second. This tends to cause drier steam, if not a percentage of superheat in the steam.

There is a system of baffles at intervals throughout the length of the steam drum. The saw-shaped part which contacts with the shell of the drum is designed to prevent sediment from lodging and endangering the shell from the temperature of the gases. The baffles are set at a slight angle and secured to the shell in a removable manner, each being provided with baffle wings, but the openings through the baffles at such points are designed so that the flow of water will be forced to travel in a zig-zag manner, and the baffles are set at such an elevation that the water traveling from the front to the rear will meet with them as with a series of dams, being agitated sufficiently to cause the globules of steam to rise to the surface, being liberated more freely than if the water flowed smoothly.

In increasing the size of the unit an additional steam drum is provided for each additional six feet of boiler width. The lack of openings is noticeable, there being one manhole at the front and one at the rear of each steam drum, with one only in each case for the two lower drums, although each lower drum may be provided with a manhole if desired.



THE CARR INCLINED WATER-TUBE BOILER

The Dake Steam Turbine

Still another turbine in which the steam is made to repeat its action upon the bucket of the same wheel, as in the Riedler-Stumpf type, is that invented by Charles W. Dake, of Grand Rapids, Mich., and made by the Dake American Steam Turbine Company, of that city. The buckets are milled into the side of the running member, or more properly into rings, one of which is shown in Fig. 1, which are bolted to a disk to form the runner, as shown in Figs. 2 and 3. A peculiarity of these buckets is that they are cut in steps, as shown in Fig. 4, which permits the better utilization of the space afforded by the thickness of the disk and preserves a more uniform distance between the discharge end of the nozzle and the wall of the buckets, as shown in Fig. 5, guiding the steam directly upon the acting surfaces and reducing the loss from the formation of eddy currents. Experiments made by the inventor show a marked increase of torque, producible with a given nozzle and rate of flow by the use of this form of bucket.

Two of these rings of buckets being assembled upon the disk, as shown in Figs. 2, 3 and 7, sets of guide nozzles, one of which is shown in Fig. 6 and the section of which appears at *A* in Figs. 7 and 8, are inclosed between them, the buckets being cut down upon a bevel at their outer edges, as plainly shown in

Figs. 1 and 4, and the nozzles being extended upon a corresponding bevel as shown in Fig. 6, confining the steam against the curved wall of the bucket.

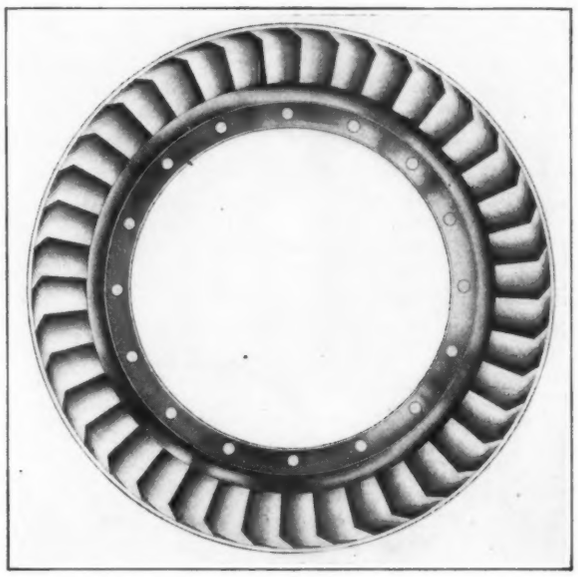


FIG. 1. A RING OF MOVABLE BUCKETS

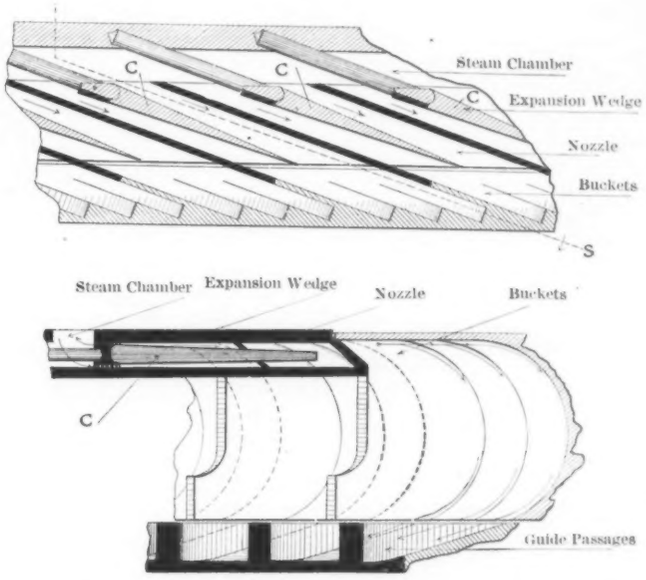


FIG. 5. DIAGRAMMATIC VIEWS OF NOZZLES AND BUCKETS

The nozzles are produced by inserting wedges *C C*, Fig. 5, into passages of rectilinear section, and the wedges may be varied to produce any form of nozzle desired, adapted to any degree of expansion with a standard form of construction.

The action of the steam is best seen in Figs. 7 and 8. Discharged by the nozzle upon the outer edge of the moving bucket *D*, it is deflected by that bucket, giving up a portion of its velocity and energy to the moving disk, and discharges into the passages of the stationary guide-block *A*, which discharges it into the moving bucket *E* of the other side of the wheel, from the outside edge of which it escapes into the exhaust passage and is carried to the atmosphere or condenser in single-stage, or, more properly, single-wheel machines—for even the single-wheel machines are compound—or to the next stage, as shown in Fig. 8, if more than one bucket disk is used.

The governor is of the centrifugal fly-weight type, direct-connected to the turbine shaft. In the simpler single-stage form this governor operates a pilot valve, which opens and closes a port that governs a piston valve. This piston valve in turn admits steam to the turbine or shuts it off, the admission being always at the maximum pressure. The governing of the multi-stage turbine is accomplished by means of a make-and-break connection of a shaft driven by worm-gearing, with a shaft connected with a rotary valve, one-quarter turn of which opens or closes the ports leading to the nozzles. The connection between the shaft sections is made by a clutch which is operated by means of a forked lever direct-connected to the governor.

The journals are supplied with lubricating oil under pressure by means of an oil pump driven by the turbine itself. In addition to this each journal has an oil ring, by means of which the lubrication

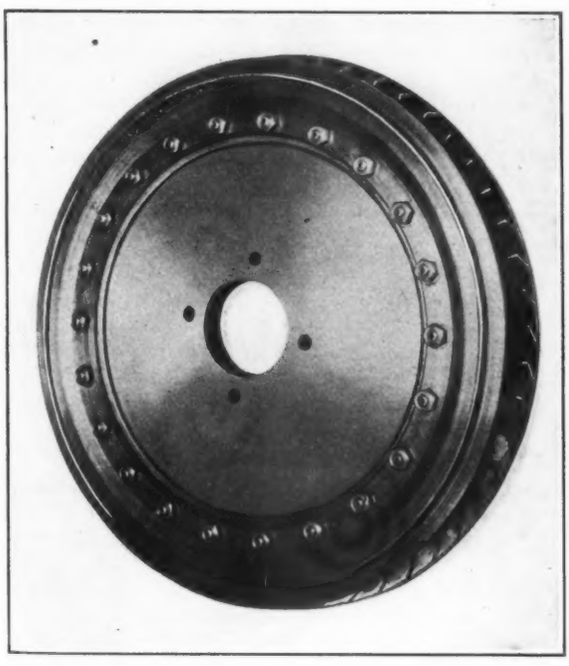


FIG. 2. THE DAKE ROTOR ASSEMBLED

FIG. 3.

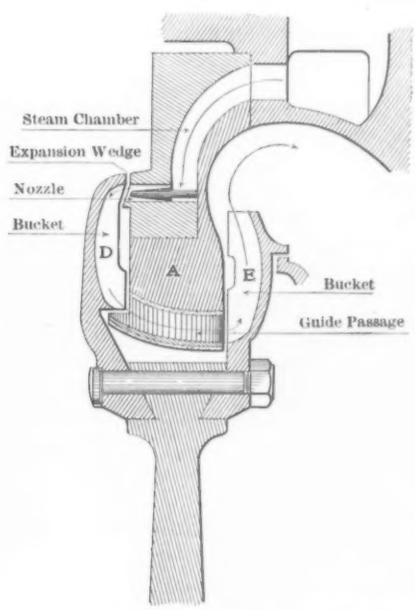


FIG. 7. SHOWING PASSAGE OF STEAM THROUGH RUNNING BUCKETS "D" AND "E" AND THROUGH GUIDE-BLOCK "A"

is continued if for any reason the supply of oil from the pump is interrupted.

The repeated action of the steam makes it possible to attain a high degree of efficiency at moderate rotative speeds, and the turbine can be built for direct-connection to electric generators, fans, blowers, etc. It is built in sizes from 15 horse-power up and may be made reversible with but little addition to the weight and complexity. Fig. 9 shows a single-stage unit of 10 horse-power.

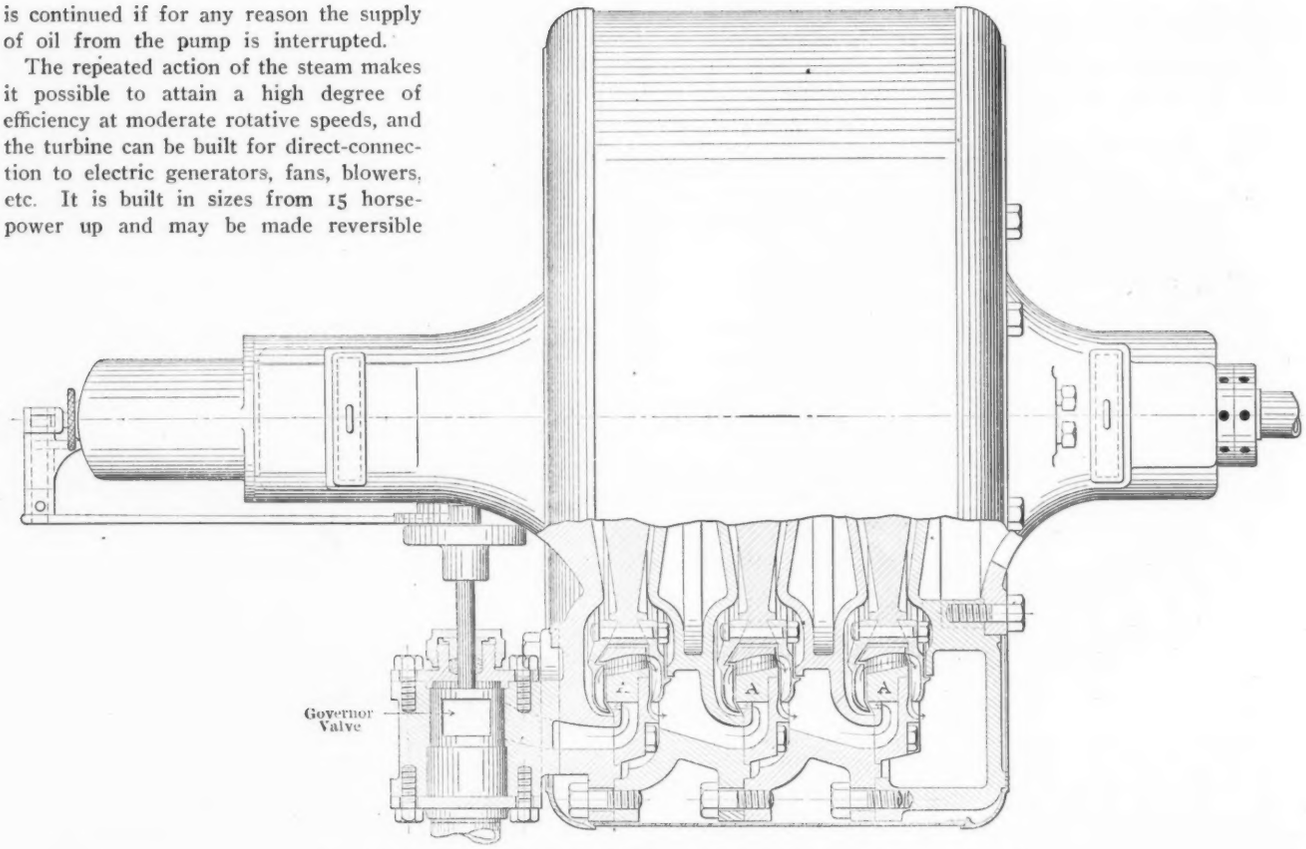


FIG. 8. THREE-STAGE DAKE TURBINE IN PART-SECTIONAL ELEVATION

American Peat Society and Government Tests of Peat

It is anticipated that the peat-fuel industry of the United States and Canada will receive a decided impetus by the organization, recently, of the American Peat Society, for the purpose of fostering the cultivation of peat lands in all North America, for industrial or agricultural utilization. It is also planned to try and induce Congress and State legislatures to establish peat experimental stations. The society was organized at a convention of "peat friends" held at the Jamestown Exposition, October 23 to 26, inclusive, when the following officers were elected for the first year:

President—Joseph Hyde Pratt, State geologist of North Carolina.

Vice-Presidents—Northeastern States, Marius R. Campbell, United States Geological Survey, Washington, D. C.; Southern States, Robert Ransome, of Jacksonville, Fla.; Great Lakes and upper Mississippi, Carl G. Kleinstuck, of Kalamazoo, Mich.; Pacific States, not filled; Canada, Dr. J. McWilliams, of London, Ontario.

Secretary — Julius Bordollo, Kingsbridge, New York City.

Treasurer—Henry G. Halloran, P. O. Box 1816, Boston, Mass.

During the meeting an excursion was

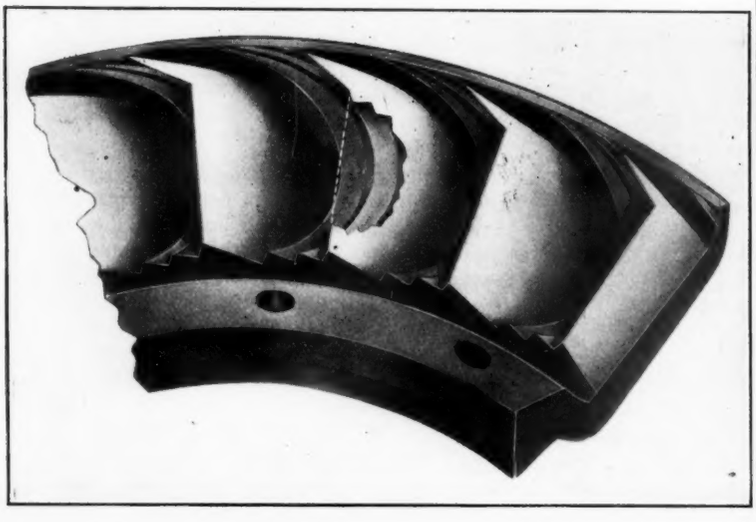


FIG. 4. DAKE BUCKET SHOWING STEPPED ROUNDING WALL AND BEVELED ENTRY EDGE

FIG. 6. A NOZZLE BLOCK

made to the famed Dismal Swamp, which is in course of drainage and reclamation, and which contains excellent peat deposits. Francis J. Bulask, president of the Commercial Artificial Fuel Company, of Toledo, O., offered to the society the free use of the company's plant for tests. The plant, which was described and illustrated in POWER for September, 1907, is located near Lambertville, Mich.

"Peat Investigations and Tests Made by the Technologic Branch of the United States Geological Survey" is the title of a paper presented by J. C. Roberts, acting engineer of the Government fuel-testing plant, in behalf of Prof. J. A. Holmes, expert-in-charge. The paper is in part as follows:

In the spring of 1907 the field investigation of the occurrence of peat was placed under the direction of Prof. Chas. A. Davis, of Ann Arbor, Mich. Professor Davis visited the more important peat-producing regions from Maine to Florida, and arrangements were perfected in Maine, Connecticut, North Carolina and New Jersey for an exhaustive field survey of peat deposits in coöperation with the State geologists. A reconnaisance examination was made by Mr. Davis of peat deposits in those States, and the methods of sampling the peat, whereby the samples should be secured from various depths, were perfected. A great many samples have already been secured.

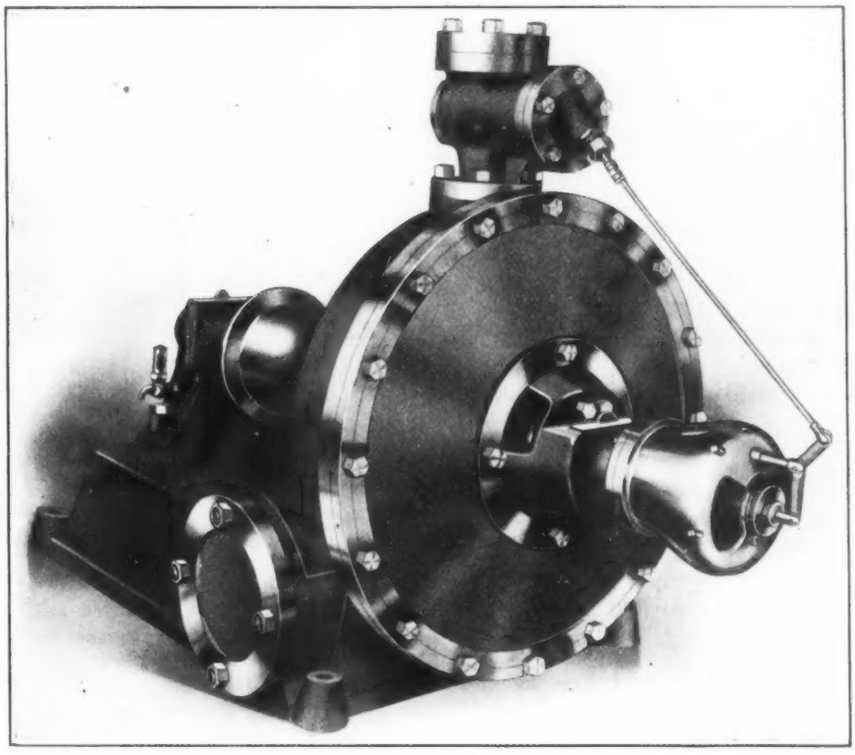


FIG. 9. DAKE SINGLE-STAGE TURBINE OF TEN HORSE-POWER

An inconclusive producer-gas test was made by our St. Louis plant in 1905, on about five tons of machined and briquet peat secured in Plymouth county, Massachusetts. The mass of peat was mascerated and pressed into briquets at the bog and dried. The amount available, however, was too small to permit of building up a fuel bed and accordingly the peat had to be deposited on a bed of Illinois coal. The result leaves in doubt, accordingly, just what part the coal played in connection with converting the peat into gas. The peat burned well in the producer and the gas was of good quality, averaging about 166.6 B.t.u. per cubic foot of gas. A comparison of this result is invited to that of Florida peat, next tested, from which 175 B.t.u. were secured per cubic foot of gas, while North Dakota lignite produced 160.6 B.t.u. and West Virginia coal 139.2 B.t.u., thus showing both samples of peat to produce a richer gas than lignite or coal.

A very satisfactory test of peat was made at the same plant in the same year on peat from Orlando, Fla., which has been disintegrated, made into briquets and dried. This peat showed a shrinkage in drying of about 45 per cent. in bulk, the loss in weight in drying being nearly 85 per cent. The dried briquets were approximately 3x6x1½-inch, and the amount furnished was sufficient in quantity to permit of a full 54-hour producer test, after building up the bed and making the preliminary trial. The total amount consumed during the run was 29,250 pounds or about 585 pounds per hour. The producer gas, as above stated, had a calorific value of 175 B.t.u. per cubic foot, and was particularly rich in hydrogen, running 18.5 per cent., and comparatively low in nitrogen, averaging about 45.5 per cent. The peat, owing to its lightness, calls for persistent firing and the amount consumed per electrical horse-power is considerably greater than that for coal or lignite. Thus for the Florida peat 3.16 pounds was consumed in the producer per electrical horse-power per hour available for outside uses, as compared with 2.88 of North Dakota lignites, and 1.03 of West Virginia coal.

A small supply of peat briquets remained after the producer test was complete and were used in making a boiler test. This was not of sufficient duration to furnish definite conclusions, though the results were very satisfactory as far as they went. No difficulty was encountered in keeping the boiler up to its rated capacity. The calorific value of the peat was 10,082 B.t.u. per pound of dry peat, as compared with 14,436 B.t.u. per pound of West Virginia coal. The amount of peat burned per electrical horse-power per hour was 6.98, as compared with 3.45 for West Virginia coal. The principal difficulty in utilizing the peat for steaming purposes as indicated by these figures, was on account of its lightness and its rapid combustion calling for persistent firing.

More recent experiments indicate that equally good results may be procured in the gas producer by merely disintegrating the drying peat, and without making it into briquets, though the latter form is doubtless essential for furnace combustion under steam boilers.

The Geological Survey fuel-testing plant is to start a series of producer-gas tests on an extended run at its Jamestown Exposition plant on peat provided by the Norfolk & Southern Railway from bogs near the southwestern portion of the Dismal Swamp in the neighborhood of Elizabeth City. This peat is being disintegrated at the plant, is dried there, and will be fed into the gas-producer in sufficient amount to secure a continued run of several days.

Other papers read at the convention were: "Peat in Ohio and Michigan," by Francis J. Bulask; "The Peat Industry and Its Possibilities in America," by Prof. C. A. Davis; "Peat Drying," by Dr. J. McWilliams; "Draining and Value of Peat Lands for Agriculture," by S. M. Woodward, of the Department of Agriculture.

Civil Service Examination

The United States Civil Service Commission announces an examination, on December 11 and 12, of applicants for the position of mechanical draftsman under the Isthmian Canal Commission on the isthmus of Panama, at a salary of $125 per month. Occasional appointments will be made at $150 and $175 per month. It is probable that 15 appointments will be made. Applicants should apply to the Civil Service Commission for application form 1312.

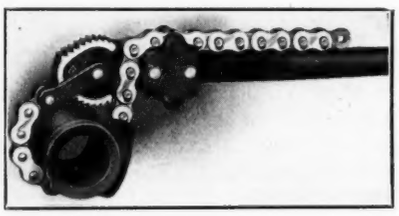
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

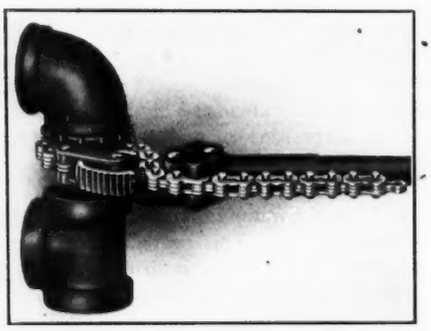
The "Agrippa" Chain Wrench

The accompanying illustrations show applications of the "Agrippa" chain wrench to



"AGRIPPA" WRENCH AS USED ON FITTINGS

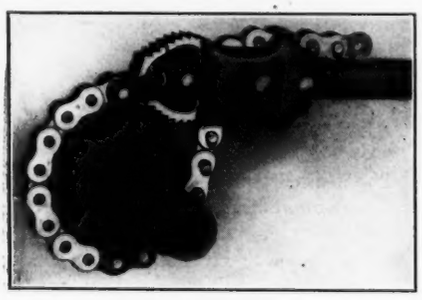
fittings, flanges and nipples. It is made by J. H. Williams & Co., of Brooklyn, N. Y., and was designed for use in awkward, narrow places where a broad-chain wrench will not answer. It will handle



"AGRIPPA" WRENCH AS USED ON SHORT NIPPLES

fittings, etc., from ⅛ inch to 12 inches in diameter.

It is of wrought steel throughout, with a drop-forged, saw-tempered jaw permanently fastened, in a milled pocket, to a powerful, solid, forged-steel handle. The chain, which is hand-made, is longer than that used in pipe wrenches, and as it swings from the center, it can be used with either side of the jaw instantly. All parts are interchangeable.



"AGRIPPA" WRENCH AS USED ON FLANGES

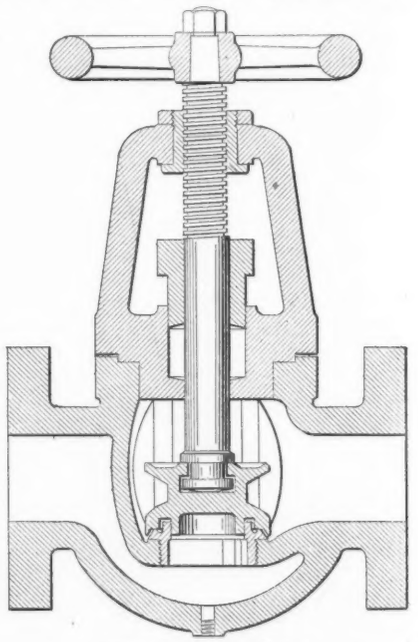
Spiral "Flexible Metallic" Packing

The Federal "flexible metallic" packing, which was described on page 568 of the August number, is now also made in spiral as well as ring form by the Federal Metallic Packing Company, 404 Atlantic avenue, Boston, Mass. This innovation is likely to appeal to engineers and supply houses alike, doing away with the necessity for making and carrying in stock a variety of special sizes, and the spiral form can be used for any and all kinds of work.

The packing is composed of an antifriction metal, compounded with graphite, made into V-shaped ribbons which are twisted to form a tube, inclosing asbestos or other material, according to the purpose for which it is to be used, the twisted strands being braided or woven in the manner shown in the illustration.

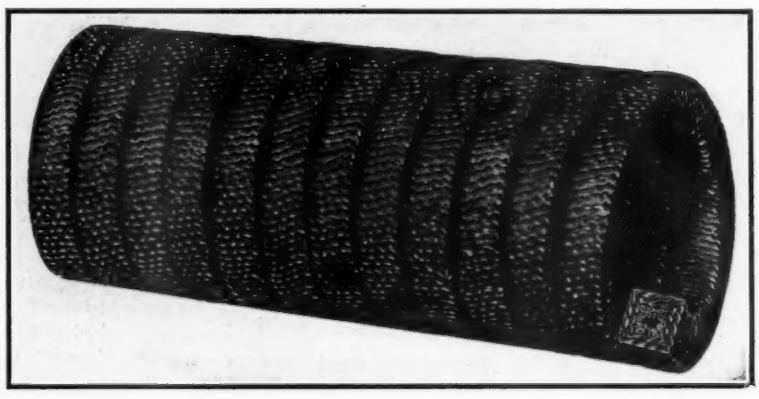
The "Edward" Valve

With the increasing use of high pressures and superheated steam the difficulty of keeping valves tight is becoming more serious. The "Edward" valve was designed to overcome this difficulty, and is built to withstand very severe duty. The essential feature, aside from the toughness of the materials used, is in designing the seat and disk, which are removable, with a view to eliminating wiredrawing. By referring to the illustration it will be seen that the opening between the disk and the seat proper, when the



THE "EDWARD" VALVE

plug is entirely free from the seat, is considerable. There are guides on the valve body to insure proper seating of the disk, and, while closing, water or steam rushing through serves to clean the disk and seat and prevent the accumulation of dirt or scale.



SPIRAL FLEXIBLE METALLIC PACKING

For superheated steam the valve body is made of cast steel, heavy enough to withstand 300 pounds pressure, and the seat and disk are of nickel bronze. For blow-

off valves the body is made of semi-steel, tested to 300 pounds working pressure, and the seat and disk are of steel bronze. "Edward" valves are built in sizes from 1 to 8 inches, inclusively, by Lammert & Mann, 157-159 South Jefferson street, Chicago, Ill.

The Ellison Throttling Calorimeter

The "Ellison throttling calorimeter," a section of which is shown in Fig. 1, consists of a steel tube 6 inches in length, of 20-stubbs wire-gage, centrally located in the steam chamber. Steam is admitted through a 1/16-inch circular orifice at *A* and a deflector is provided at *B* to insure the diffusion of the steam about the thermometer-well. The area of the orifice is such that the steam is expanded to about atmospheric pressure, the pressure actually existing in the steam chamber being measured by a mercury U-tube.

Six sets of sampling nozzles are furnished, made of ½-inch tubing closed at the ends and perforated with twenty ⅛-inch holes equally distributed about their cylindrical surface, in accordance with the form prescribed in the revised code of the American Society of Mechanical Engineers. This calorimeter is made by the American Steam Gauge and Valve Manufacturing Company, Boston, Mass.

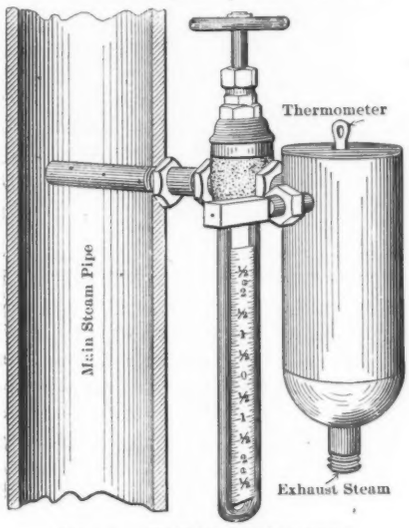


FIG. 2. ELLISON CALORIMETER

sists of a steam chamber 2 inches in diameter and 6 inches in length, surrounded by a jacket 3 inches in diameter and 7 inches long, leaving an annular ½-inch space which is packed with lamp-black to prevent radiation. The retention of heat is further favored by nickel-plating and brightly polishing the entire exterior of the instrument. The thermometer-well

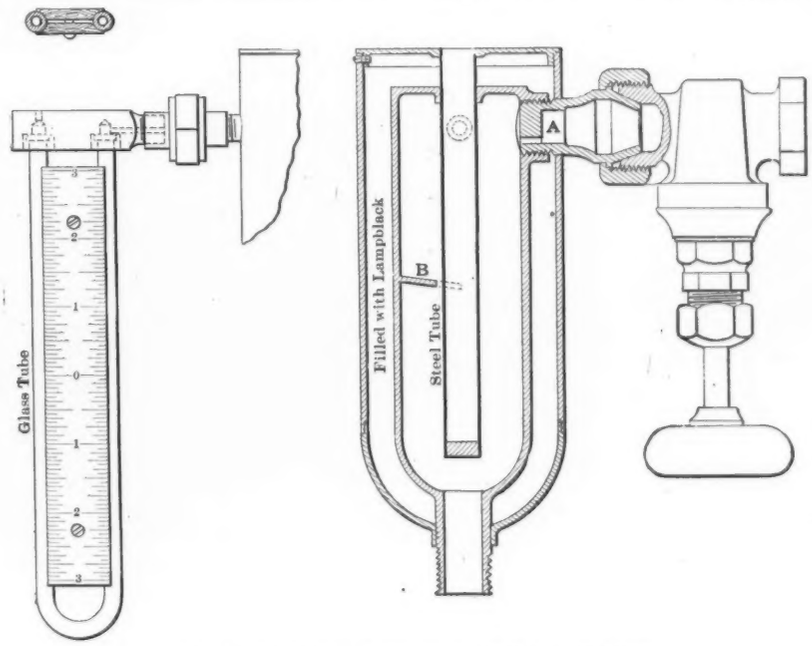
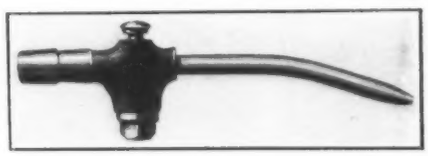


FIG. 1. SECTIONAL VIEW OF ELLISON CALORIMETER

Improved Air Nozzle

The Lunkenheimer Company, of Cincinnati, recently placed on the market the air nozzle shown herewith, for use wherever compressed air is available. The shank is made suitable for a ¼-inch pneumatic hose, the valve is easily handled and controlled, and the desired volume of air can be obtained by simply pressing the button on the top.



AN IMPROVED AIR NOZZLE

Automatic Force-feed Cup

The leading object in the mind of the designer of this cup was to produce a cup at low first cost which would be effective in its operation and convenient for use. The descending member at the left is reciprocated by a rod leading to any convenient part of the machine. It carries a pawl consisting of a thin plate of steel separated into a narrow and a wider blade. The narrower blade at the left continually engages the ratchet wheel and turns it ahead a given number of teeth at each reciprocation. This left-hand ratchet wheel carries with it the two contiguous plates, into the opening formed by which the wide blade can dip and move the right-hand ratchet wheel forward a given number of teeth with each revolution of the shaft. As the distance between the projections upon the middle plate is adjustable, the number of teeth exposed can be regulated and the rate of feed governed. The worm-gear is rotated only when the wider pawl works and conveys its motion to the plunger in an obvious manner. The cover carrying the worm-gear is clamped upon the cup and can be removed by a single motion. The device is ingeniously simple and is manufactured by the Dynamic Grease Company, 352 Bullitt building, Philadelphia, Penn.

AUTOMATIC FORCE-FEED GREASE CUP

"Albany Grease" Cup for Loose Pulleys

One of the chief reasons why loose pulleys give engineers a great deal of trou-

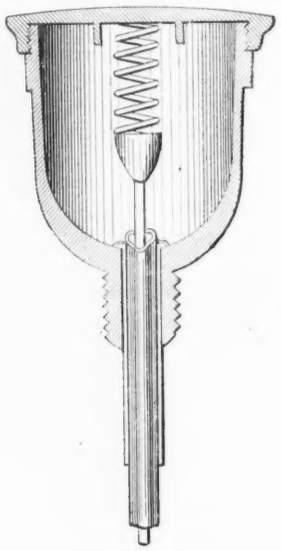


FIG. 1.

ble is improper lubrication, and one of the principal remedies for this condition is the application of a proper lubricant at the proper place and in the proper manner. To help this desirable consummation along, Adam Cook's Sons, 313 West street, New York City, have placed on the market the loose-pulley grease cup shown in section in Fig. 1, with a recommendation, of course, that "Albany Grease" be used in it.

The special feature of the cup, as

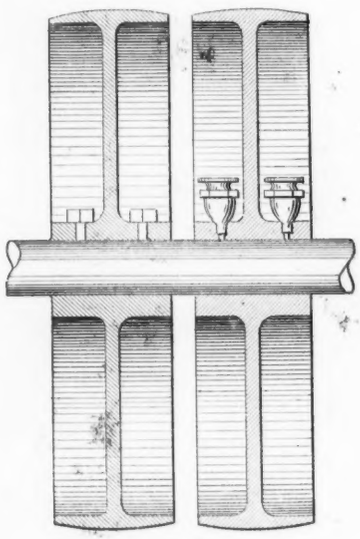


FIG. 2.

pointed out by the makers, is in the tube and interior spindle, the latter being held always in contact with the shaft by the spring, thereby conducting the slightest variations in shaft temperature into the lubricant in the cup, no matter what the position of the cup or the speed of rotation of the moving parts. This insures the softening of the grease at the right time and to the desired extent. Furthermore, it is stated that if a grease is used the body of which maintains its consistency under all conditions except temperature increase, centrifugal force will not interfere with lubrication, nor will there be any undue flow of lubricant to the shaft. On the contrary, only the grease adjacent to the spindle will liquefy and be drawn to the point of feed by capillary attraction in just the quantity needed and when needed. When the pulley is at rest the flow of grease stops, of course, obviating drip and waste.

It is stated that mineral greases cannot be used in this cup, as they will not retain their consistency and will not flow as desired; also that animal greases containing impurities which have been added to give them weight will clog the spindle tube.

Attention is directed to another advantage in using a grease of the character for which the cup was designed, that is, the avoidance of damage to belts due to lubricant dropping on them, a condition which increases fire hazard, not to mention the annoyance to the engineer.

Fig. 2 shows how and where "Albany Grease" cups ought to be installed on the loose-pulley shaft.

Fort Wayne Direct-current Motor

The accompanying engravings illustrate a line of small direct-current electric motors which the Fort Wayne Electric Works, Fort Wayne, Ind., has brought out for the "general utility" class of work, such as driving job printing presses, laundry machinery, coffee grinders, etc. As Fig. 1 shows, the motors are of the semi-inclosed, or ventilated, type, with protecting cages at the ends of the field-magnet frame. This engraving shows a motor intended to be mounted on the ceiling, but the machines are, of course, also built for floor mounting. Both forms, when so ordered, are equipped with sliding rails for belt adjustment and drip-pans for catching any oil that may escape from the journal boxes.

The field-magnet yoke is of cast steel, and the magnet cores are integral parts of the casting, as indicated by Fig. 2. The pole-shoes are laminated and held to the ends of the magnet cores by bolts which pass through the yoke-ring and magnet core. All of the motors of this line (type L) are bipolar and the frames are cast with low, wide foot-lugs, giving stability of support and low center of gravity.

The field-magnet coils are form-wound, taped with linen tape and treated with a special insulating compound. The coils are held on the magnet cores by the pole-shoes.

The leads of the coils are brought out to a terminal block where all connections are made, thus doing away with the danger of loose connections inside the frame. All lead connections on the outside are soldered.

The armature core is built of laminations of soft annealed sheet steel, japanned before assembling on the shaft. The slots for the armature windings are

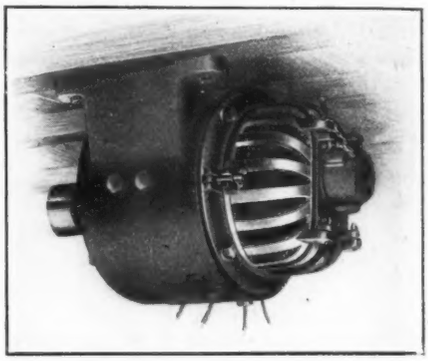


FIG. 1. FT. WAYNE BIPOLAR MOTOR

also punched in the laminations before assembling, and filed after assembly wherever this is necessary in order to remove any sharp corners or irregularities that may exist. The armature coils are form-wound and insulated with linen tape and a high grade of insulating varnish. As an extra precaution the slots of the core are also insulated with a specially prepared insulation. All coils are given an insulation test before assembling to make sure of the absence of moisture and the degree of insulation. The coils are made of insulated copper wire with no soldered joints except at the commutator, where the leads or ends of the coil connect to the commutator segments. The commutator segments are made of a high grade of

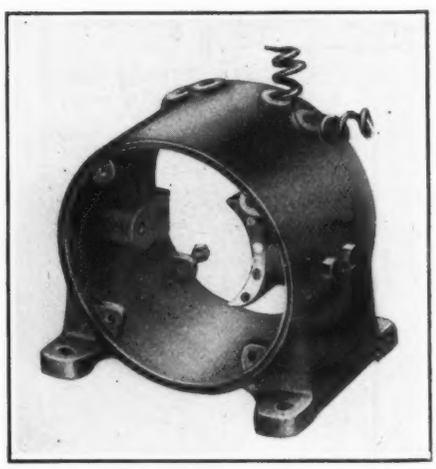


FIG. 2. FIELD MAGNET; ONE POLE-SHOE OFF

hard-drawn copper and carefully insulated by a special grade of mica which is said to possess that important wearing quality so necessary to the successful operation of a direct-current motor, that is, it wears uniformly with the wear of the commu-

tator bar. The brush-holders are of the box type, the brushes being pressed against the commutator by the extended ends of flat spiral (not helical) springs.

The bearings are of the ring-oiling type, equipped with phosphor-bronze sleeves inserted in the bearing case which is a part of the end flange. The sleeves are grooved so that oil brought up on the shaft finds its way through these grooves and lubricates the shaft for the full length of its bearing surface. The bearing case is machined on the inside to fit accurately the outside of the bearing, which is reinforced in the center for about ½ inch in width. This serves as a pivot and makes the bearing self-alining, and, being once adjusted, they are securely held by self-locking set-screws.

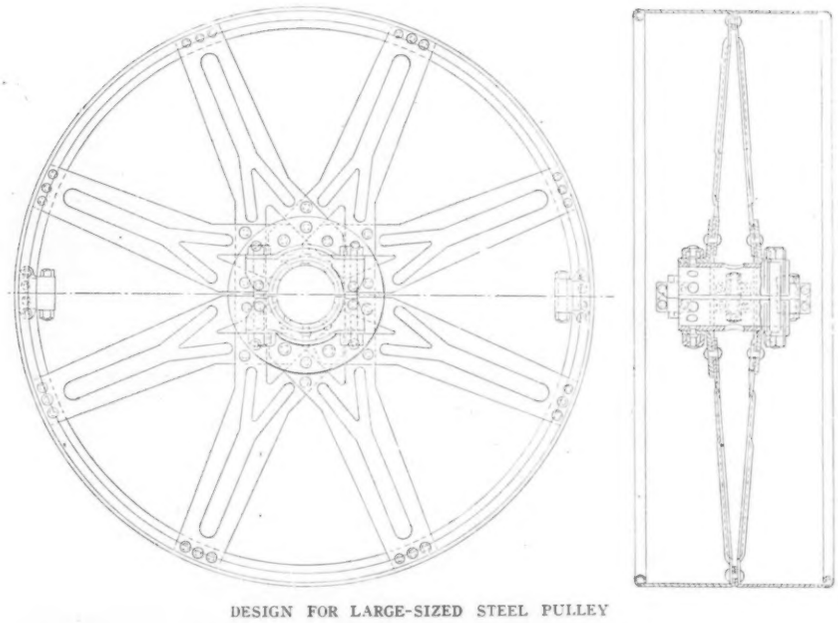
Type L motors are made in sizes ranging from ¼ to 2 horse-power and are wound for 115, 230, or 550 volts. They will operate satisfactorily, however, on voltages varying 5 per cent. from rating, at correspondingly different speeds. The motors are guaranteed to stand an overload of 50 per cent. for one hour, or 100 per cent. overload momentarily without injurious heating or requiring adjustment of the brushes.

New Design for Large-sized Steel Pulleys

Herewith is illustrated a new design for 44-, 46- and 48-inch parting pulleys, 6- to 16-inch faces, recently put on the market by the American Pulley Company, of Philadelphia.

The pulley shown is 44 inches in diameter and has a 14-inch face. The eight arms in the large sizes, instead of six, made of wider metal and secured to the rim flanges by three rivets for each arm.

As will be noted, the arms widen as they approach the hub, and are bifurcated and corrugated to increase the strength. As in the smaller pulleys, diameters and faces advance by 2-inch gradations, so that the total range of sizes which can now be had of this standard type of pulley is from 6 to 48 inches in diameter, with from 2- to 16-inch faces, according to diameters.

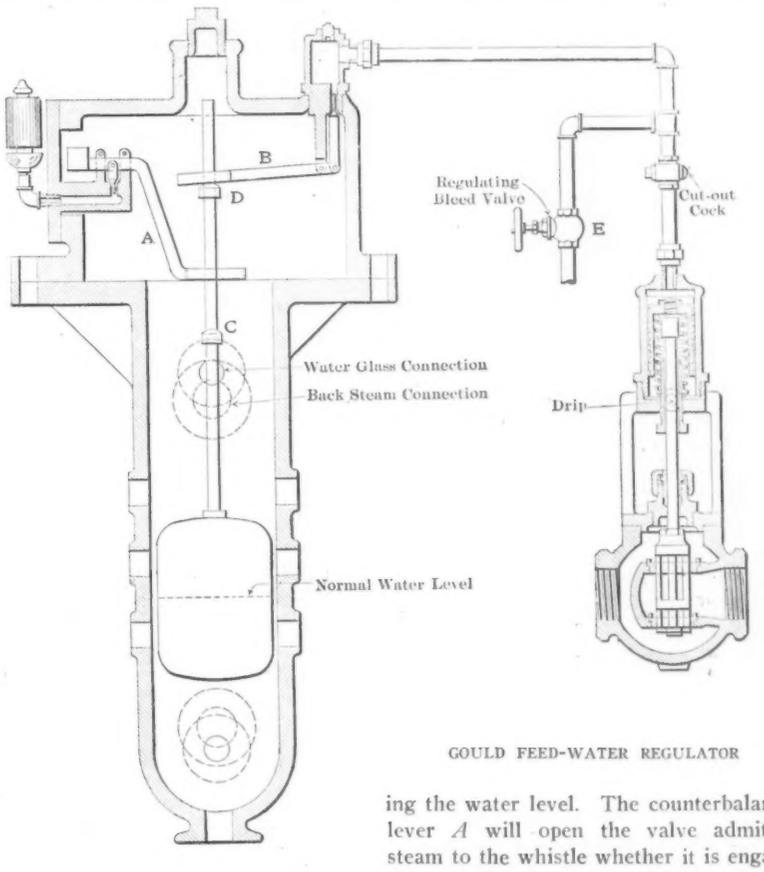


DESIGN FOR LARGE-SIZED STEEL PULLEY

essential difference between these and the smaller sizes made by this company is in the arrangement of the arms, there being

The Gould Safety Continuous Feed-water Regulator and High- and Low-water Alarm

In this device one float is made to sound the alarm for either high or low water and to control the regulator for preserving the water level. The counterbalanced lever *A* will open the valve admitting steam to the whistle whether it is engaged by the collar *C* in case of high water, or by the collar *D* in case of low water.



GOULD FEED-WATER REGULATOR

The speed of the feed-pump is controlled by the regulating valve shown in section at the right. This is a balanced double-seated valve, held open by the action of a coiled spring. When the water has become sufficiently high, the collar *D* engages the forked end of the lever *B*, opening the valve which admits steam to the top of the spring-actuated piston, and closes the pump-regulating valve. The valve *E* is simply cracked from its seat in order to insure the discharge of this pressure after the valve on the column is seated. Particular attention has been paid in the design of this regulator and its column to the convenience of the man who will have it in charge. Notice that the top of the column containing all the operating mechanism may be removed by opening one union, and that the high- and low-water mechanism may be removed entirely without disturbing the rest of the column or opening a single pipe joint. It is made by the Safety Equipment Manufacturing Company, 1200 Fisher building, Chicago, Ill.

"Climax Smoke Preventer"

In this apparatus the steam-jet principle is applied, in conjunction with revolving dampers, with intent to provide the requisite amount of air across the fire-bed in a furnace, to promote practically perfect combustion and thereby reduce smoke to a minimum, even when burning bituminous coal. Fig. 1 shows the construction of the steam inlet nozzle and the form of air damper used. These are usually applied to the front of the boiler, as shown in Fig. 2, arranged to work automatically when either fire door is opened, by means of the arm-and-pin contact shown. Opening the door causes a rack and pinion arrangement to actuate the rod which in turn operates the steam valve and opens the air dampers. The valve *V*, which is seen at the right, has a special thread on the stem so that a half turn opens the valve fully. As will be seen, it is impossible for the fireman to open the door without putting the device in operation. The length of time that the steam jet and draft are allowed to blow across the fire varies according to conditions, but they remain on until shut off by the fireman, usually about five minutes after each firing.

The inlet for the steam is between 1/16 and ⅛ of an inch in diameter. If it should become clogged, it is only necessary to shut off the steam, open the pet-cock and clean out the nozzle with a wire. An especial system of baffle-plates is provided to reduce noise to a minimum. The steam used is taken from the boiler, of course, and equally of course only a small amount is required. Fig. 3 shows how the jet is thrown across the fire-bed.

This apparatus is made by the Climax Smoke Preventer Company, Equitable building, Boston, Mass.

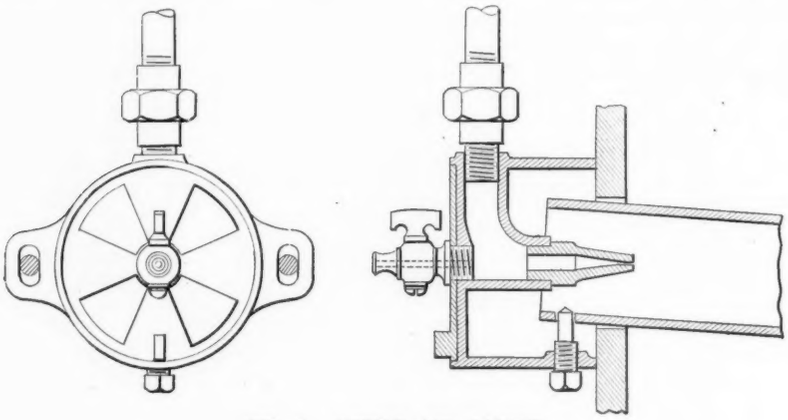


FIG. 1. NOZZLE AND DAMPER

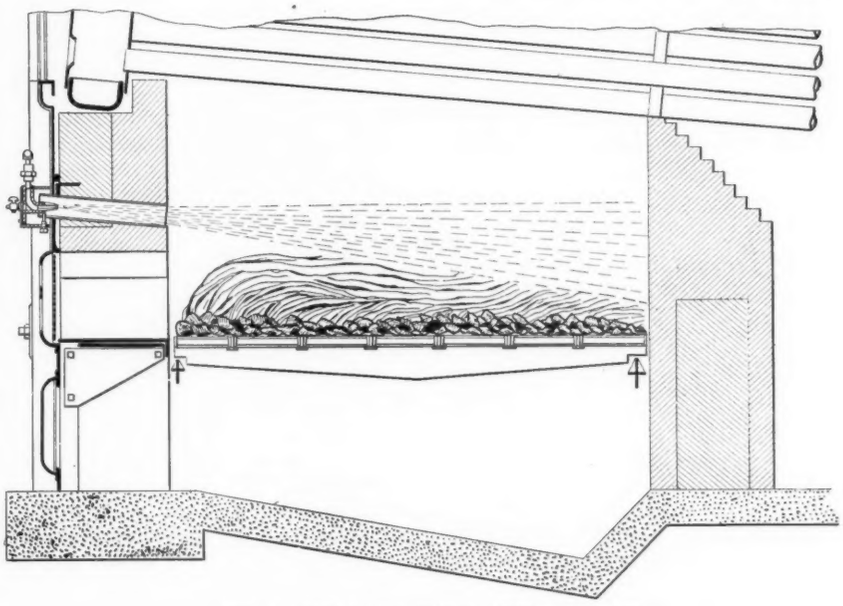


FIG. 3. STEAM JET BLOWN ACROSS FIRE-BED

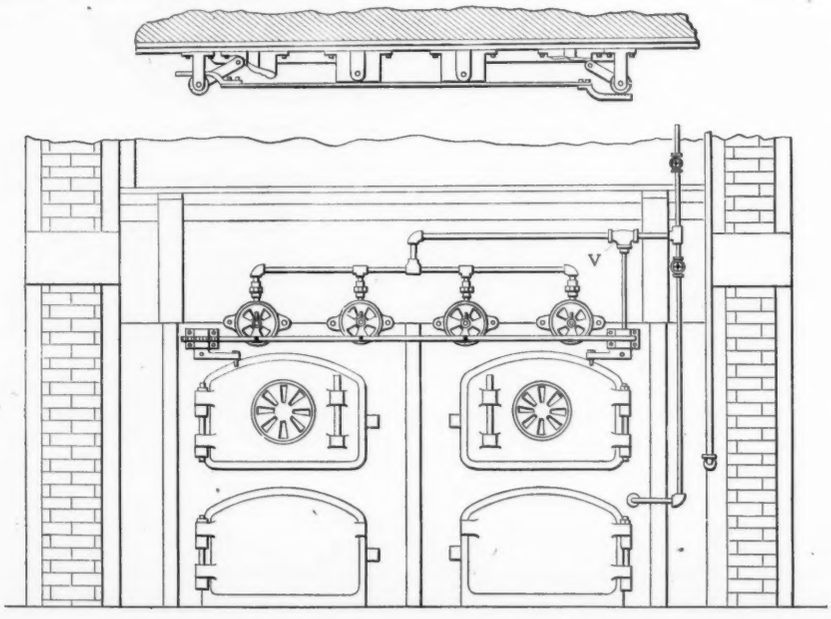
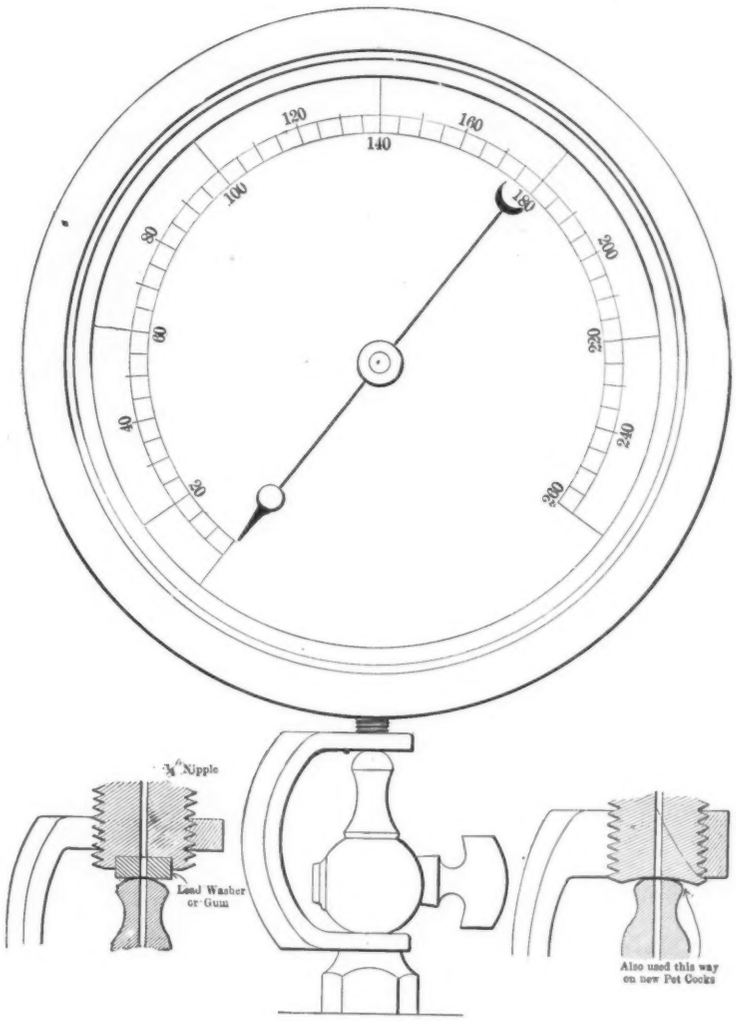


FIG. 2. SHOWING APPLICATION OF CLIMAX SMOKE PREVENTER

Device to Connect Gages to Pet-cocks

The accompanying engraving shows a little attachment for connecting a gage to a pet-cock. It frequently happens that pressures are to be tested in tanks, boilers or pipes where pet-cocks are used for draining or sampling. By connecting the test gage to such a cock the other gages may be left in position and compared with the testing gage, and it is of course more convenient and more economical of time to connect the gage to an existing outlet like the pet-cock than to make an outlet by removing another gage or fitting. When the pet-cock is new a sufficiently tight joint can be made by counter-sinking the nipple of the test gage; but in order to adjust the gage to whatever connection may be found it is well to recess the end of the gage nipple and insert a washer of lead or rubber to insure a tight joint.

The one-quarter inch connection is in such general use that the connector is made to this standard. The connector was invented and is for sale by E. J. Clarke, 1305 Linden street, Scranton, Penn.



DEVICE FOR CONNECTING GAGES TO PET-COCKS

"Lackawanna" Shaking Grate

This grate has the unusual, and possibly unique, feature of ⅛-inch air spaces in a class of grate on which can be burned any size of anthracite smaller than buckwheat, as well as slack, sawdust, etc., without the fuel being in danger of falling into the ash-pit, and with considerably better combustion than if the air spaces

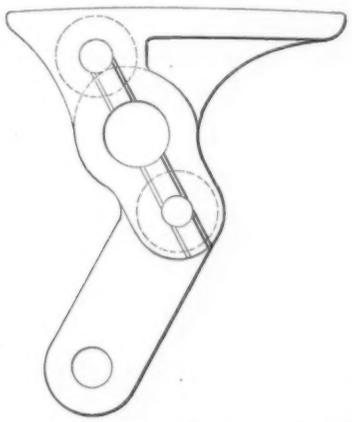


FIG. 1. ONE OF THE SEGMENTS

were larger. The grate consists practically of rows of knife-like segments, Fig. 1, assembled upon and bound together by wrought-iron rods, the segments being interlocking. This form of construction not only allows amply for expansion and contraction, but it renders the removal of parts easy. For instance, if a bar becomes damaged it means at the most the replacement of a few segments,

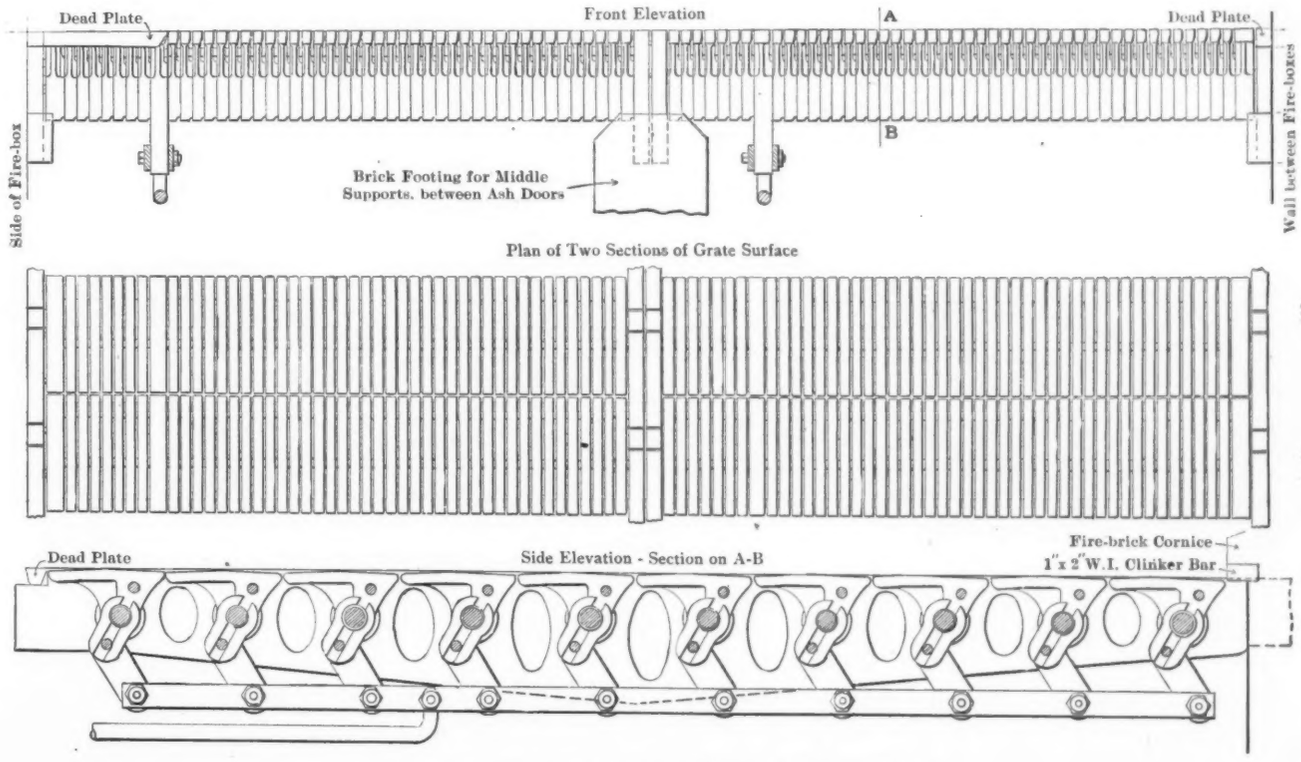


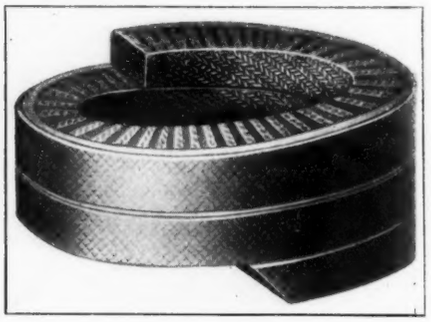
FIG. 2. PLAN AND ELEVATION VIEWS OF LACKAWANNA GRATE

which can readily be done by removing a nut at the end of the affected bar and taking out the segments to be replaced. By reference to Fig. 2, it will be noticed that there are no projections which can be burned off.

The "Lackawanna" grate is made by the Lackawanna Grate Bar Company, of Scranton, Penn.

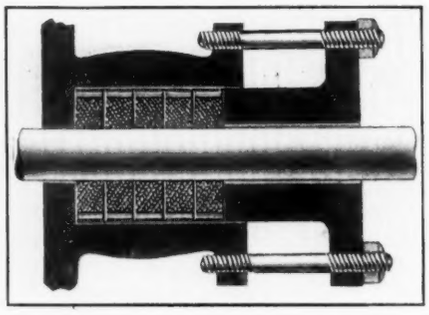
Chesterton's "Rubberbestos" Spiral Packing

In this packing the improvement claimed consists in the diagonal position of the



CHESTERTON'S "RUBBERBESTOS" SPIRAL PACKING

plies of cloth forming the body of the packing. Instead of running at right angles to the rod they are arranged in this diagonal manner with a view to affording greater compressibility, and the manufacturers claim that it will not only give better results this way, but will be from 50 to 100 per cent. more durable. Another feature to which attention is called is the position of the elastic back which is placed on the outside to afford better protection from the heat, and also to permit expansion directly on the rod. This construction also forms an elastic



HOW "RUBBERBESTOS" SPIRAL PACKING IS APPLIED

cushion to allow for the play or vibration of the rod. "Rubberbestos" packing is made by A. W. Chesterton & Co., 64 India street, Boston, Mass.

Schultz "Non-bursting" Steel Fly-wheel

Having in view the elimination of disaster due to wrecked fly-wheels, George W. Schultz, of St. Davids, Penn., has patented an engine fly-wheel which he believes will be "non-bursting." The rim is to be built hollow, in sections, with steel-wire rope wound around on the inside until the proper rim weight is attained; or any other suitable filling may be used, such as chains, wire rods, round iron or steel, and even concrete or sand. The inventor reasons that as wire rope has many times the tensile strength of cast iron, and when wound in layers is not much bulkier, weight for weight, a rim made up of one continuous length of wire rope would not be likely to burst, and in case of accident the wheel could not fly from the shaft.

The rim casing is to be composed of riveted steel plates, with the top plates arranged to overlap halves of sections, locking them together. The rim sections will also be secured in position, before winding, by one or more lengths of wire cord, or cable, shorter than the circumference, drawn together by means of turnbuckles, as shown in Fig. 2. Provision is to be made for hollow spaces in the rim in which weight may be placed to allow for counterpoise for the weight of the crank-shaft.

Instead of one central spoke engaging each rim section, it would be preferable to use two parallel flat-steel spokes, riveted to rim and hub, with space between, to prevent lateral sway and to permit of a certain amount of elasticity to take up shock or vibration.

The hub would be of steel or iron forging, pressed steel, or cast iron, and being in sections it could be attached to the engine shaft without having to re-

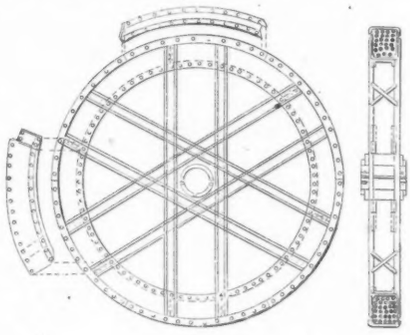


FIG. 3.

move the shaft from the pillow-block. The hub sections would be reinforced by flanges or lugs, as indicated in Fig. 3. It might be desirable in some instances to employ angle-irons for side braces, to further strengthen the wheel. The materials for the wheel could be obtained and set up anywhere, and wire rope of any diameter will do to weight the rim.

Mr. Schultz believes that such a wheel could be driven safely at many times the rim speed allowed for a cast-iron wheel.

The illustrations show two proposed styles of the Schultz wheel.

Wildt Steam Blower

To provide forced draft for burning small sizes of anthracite and low-cost fuels generally, the Wildt steam blower is presented as a blower of great strength, using very little steam. It consists chiefly in an inner and outer tube (Fig. 1), with

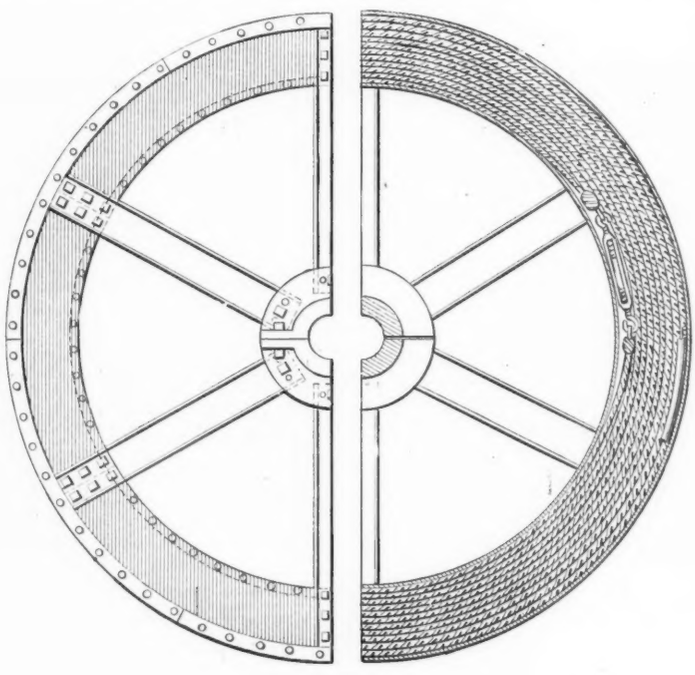


FIG. 1

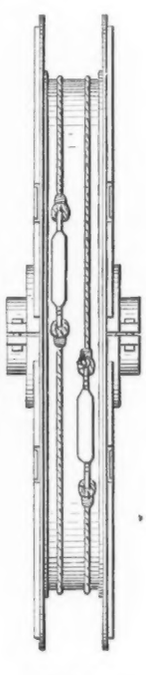


FIG. 2

an annular space between, and with ports so disposed as to cause the blowing steam to take a circular, or spiral, path, the steam naturally taking along more or less air with it into the furnace. By regulating the flow of steam, of course, the blast is regulated as desired.

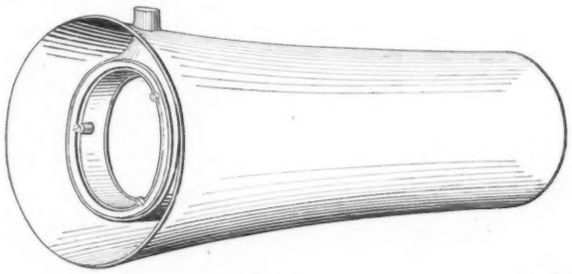


FIG. 1

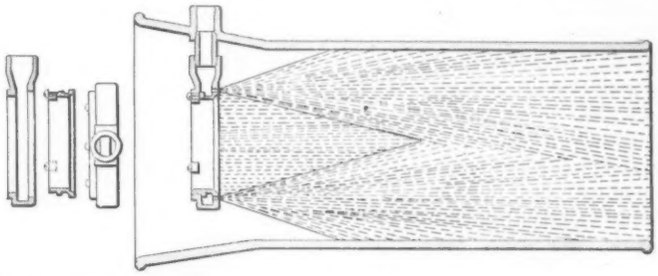


FIG. 2

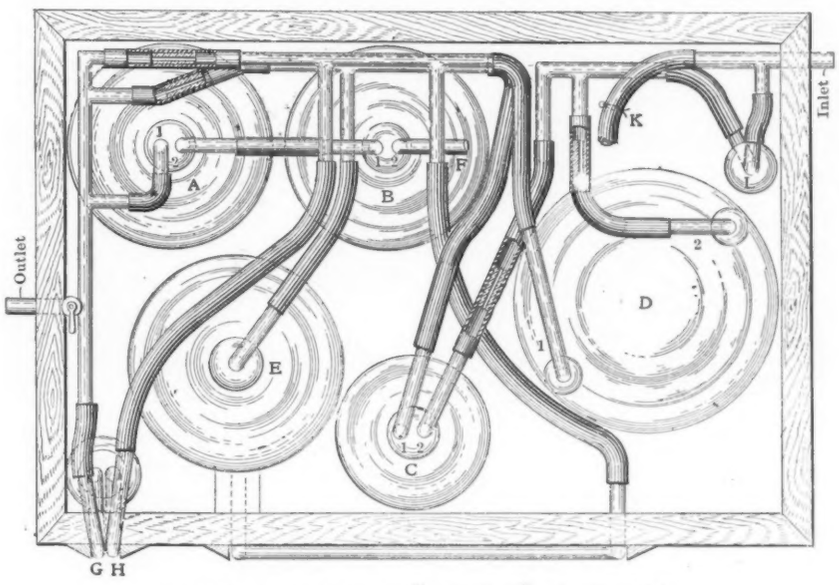
WILDT STEAM BLOWER

There are so few parts and the construction is so simple that it is not likely to get out of order. If dirt should lodge between the tubes, however, the inner tube can be taken out easily and the dirt removed. Fig. 2 indicates approximately the action of the steam jet in the blower, which is made by the Lackawanna Grate Bar Company, of Scranton, Penn.

The American CO_2 Indicator

This apparatus, designed for the automatic and continuous determination of a constituent of gaseous mixture, is intended to be used with any mixture of gases where one constituent can be absorbed by a suitable solution. It is being introduced for the determination of CO_2 in flue gas, the percentage of which at once indicates the amount of excess of air that is being allowed to pass through the furnace, a very important matter where the economic use of fuel is at all considered. In a steam plant, for instance, the heat contained in the fuel is required to raise steam instead of heating air which passes into the flue; also in producer gas, when the CO_2 should be kept as low as possible, the existing conditions are known at once by the use of some such apparatus. Another very important use will be in the manufacture of illuminating gas, for the control of the CO_2 in the water gas before it is carbureted.

The principle of the apparatus is based upon the difference between the normal tension of the gas and the tension after the constituent has been absorbed. The gas enters at the inlet and is carried through the various chambers by suction applied to the outlet, so that there is a continuous stream of gas passing through the instrument. Upon entering, the gas passes into the upper end of a filter tube *L* which is filled with cotton to take up all soot and dirt which might otherwise clog the tubes. From the bottom of the filter the gas is passed to a tube which divides it into two streams, both streams passing through capillary tubes. One stream enters the potash chamber *D* through the tube *D 2*, which dips under the solution so that complete absorbtion of CO_2 takes place as the gas bubbles through it; the gas then leaves it by the tube *D 1*, passes along the tubes through a second capillary, and so on to the outlet. The second stream, after passing the capillary tube, enters the chamber *C* through the tube *C 2;* this chamber contains oil, under which the tube dips, so as to give the same resistance to the passage of the gas as there is in the chamber *D*. The gas then passes on through the tube *C 1* and a second capillary, after which it unites with the first stream and passes out.



INTERIOR PLAN VIEW OF "AMERICAN" CO_2 INDICATOR

The chambers *A* and *B* contain a solution of sulphate of zinc and are used to regulate the amount of suction used in the apparatus; this suction is shown on the vertical tube *G*. The chamber *D* is connected through the extension of the tube *D 1* with the upper end of the manometer tube which is mounted in an inclined position on the front of the apparatus; it is also connected with the tube *H*, where the tension in *D* is shown. The lower end of the manometer is connected with the oil chamber, through the continuation of *C 1* and the aspirator bottle *E*.

There now exist in the apparatus two tensions exactly alike, called the normal tension, each opposed to the other by being applied at each end of the manometer tube, which holds the oil in the manometer at 0 as long as there is no absorption. Should there be any CO_2 in the gas it will be absorbed by the potash in the chamber *D*, thus causing a higher tension in this chamber. The two tensions then being unequal, the result is shown on the manometer scale instantly.

The suction needed at the outlet is about 2 to 3 inches of mercury. This is reduced and regulated by the depth of seal in *A* and *B*, and by the use of the small cock at the outlet the amount of air allowed to pass through *A* and *B* is also regulated. It will now be found, that as the suction which is registered by the tube *G* is increased, the tension in this tube and that in the potash chamber, which is shown in the tube *H*, will be equal, until the resistance to the passage of the gas through the solution and capillaries is overcome; after this the rise in *H* is only one-half that in *G*, so that one can get any difference between the two tensions that one desires. It is only necessary then to divide this working difference into 100 parts, when each part will represent 1 per cent., as total absorption would be practically closing the inlet, when, of course, the two columns of solution would come together.

The aspirator bottle used as the lower

end of the manometer being very wide practically has no rise nor fall, and all the movement is shown in the tube. This tube is set at an incline rising 1 in 10 which multiplies the movement by 10, so that one fiftieth of an inch rise, which represents 1 per cent. of CO_2, is shown by a movement of one-fifth of an inch and is readily read.

The apparatus is stated to be so sensitive that it will readily show the CO_2 in the breath, and a spark at the end of a match will produce enough CO_2 to be indicated on the scale. All indications are taken in about 40 seconds. It is made by the Jones-Julia Manufacturing Company, 4 Stone street, New York City.

Fly-wheel Accident at Washington, D. C.

By J. B. Baker

The bursting of the fly-wheel of an electric-light engine in the National Hotel, Washington, D. C., early in the morning of October 29, presents some interesting features. The generating plant of which the damaged engine is a unit includes two similar Watertown engines, with 5-foot 6-inch fly-wheels, the cylinders stated to be 14x14 inches and supplied with steam at 60 pounds pressure, the engines being direct-connected to 75-kilowatt, 125-volt, 600-ampere, 270-revolutions per minute General Electric generators; and a smaller engine of another type belted to an old bipolar generator. Both Watertown engines were equipped with fly-wheel governors of the old Watertown type (with eccentric disks on the outer ends of the fly-wheel hubs) inclosed by fixed governor shields.

It has been customary to operate the smaller set during the night, starting one of the larger sets at 6 a.m., to carry the morning load; and running both of the larger sets in the evening. The normal speed of the wrecked engine was 260 revolutions per minute, required to keep the generator at 110 volts. The boiler equipment, which at present consists of two old-style Campbell & Zell water-tube boilers, is being replaced by new boilers of larger capacity.

The engineer who was on duty at the time of the accident told the writer that he had started up the set in question some little time before the trouble occurred and was standing in the fire room about one hundred feet distant. The first intimation he had of anything going wrong was a noise from the engine room—a loud, ringing blow, which he thinks was caused by the larger of the governor weights striking the governor shield. He ran toward the engine, but before he could reach it the fly-wheel let go. The room was immediately filled with steam, but the engine shut itself down, and he managed to reach the throttle valve quickly.

Pieces of the fly-wheel had gone through the ceiling of the engine room, which was of old-fashioned construction, with rather heavy spruce and hemlock timbers, and then on into—but not through—the ceiling of the room above. The noise and the fact that the lights went out alarmed the guests to some extent. Fortunately the room over the engine room was unoccupied, so no one was hurt.

In what follows the figures relating to the apparatus involved and the details of the damage are approximate only. Examination showed that the fly-wheel was almost all gone—the only portions left on the engine being the hub, of 11 inches outside diameter over a "5-inch" (4 15/16-inch) shaft, and short stumps of the six spokes, or arms. The general appearance of the hub is fairly shown in Fig. 1, which was taken looking toward the engine cylinder from a point beyond the other end of the bed-plate. The arms are of rough elliptical section, 5x2½ inches at the breaks, and the six remaining stumps vary from 2¼ to 3½ inches in length.

Accepting the night engineer's theory of the accident, that the larger weight of the governor flew off, striking the governor shield, the loss of the weight must have allowed the governor spring to contract, opening up the engine to the limit and causing it to race until the fly-wheel burst. Furthermore, when this occurred pieces of the wheel projected toward the cylinder end of the engine might have wrecked the valve-gear, which would account for the immediate shutting down of the engine. Yet it is not evident what caused the governor weight to let go—unless, indeed, the fly-wheel arm through which the main pin of the governor mechanism passed (Figs. 4 and 5) gave way on account of a flaw.

When the wheel burst, pieces flew in all directions, the rim being separated into three large pieces 22 to 24 inches long, several pieces 10 to 14 inches long, and a number of smaller pieces. A section of one of the large pieces is shown in Fig. 2. There are three main holes in the ceil-

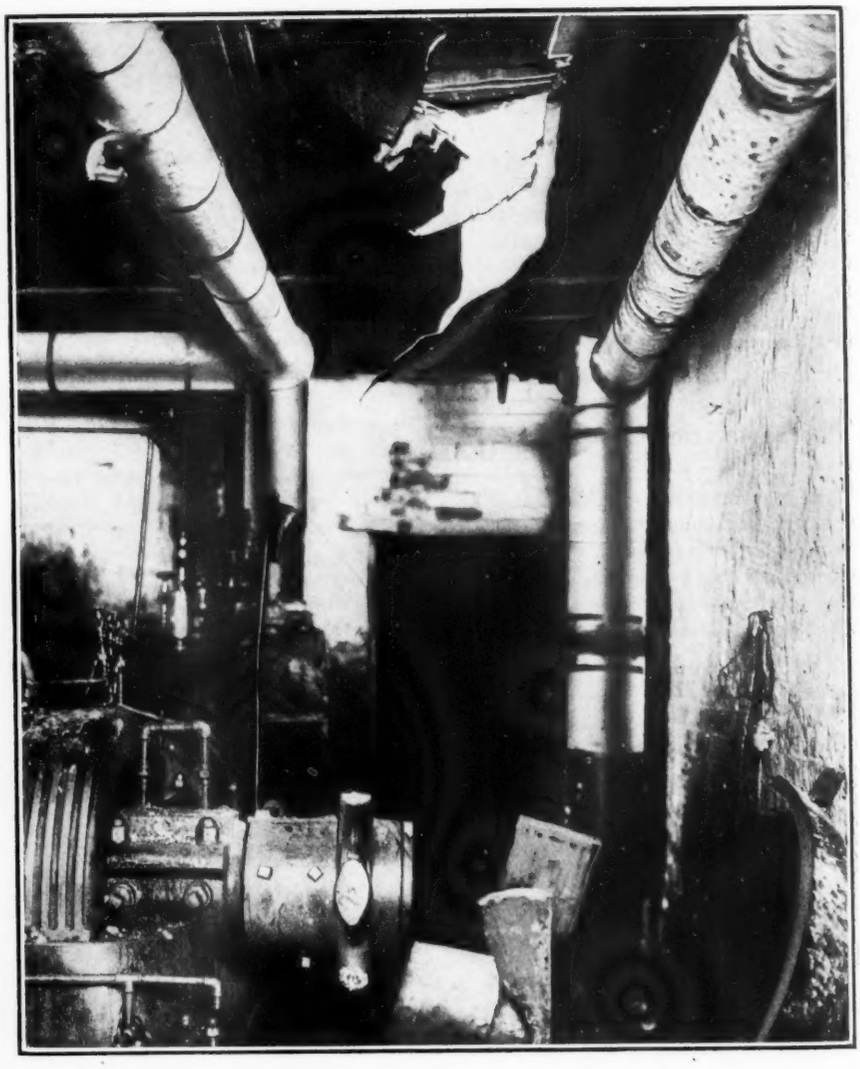


FIG. 1. FLY-WHEEL WRECK AT NATIONAL HOTEL, WASHINGTON

ing of the engine room: a 2x4-foot opening directly above the wheel, one end of the hole being visible in Fig. 1; a 4x6-foot hole in line with the wheel (toward the camera) about seven feet from the first hole; and a 2x4-foot hole about

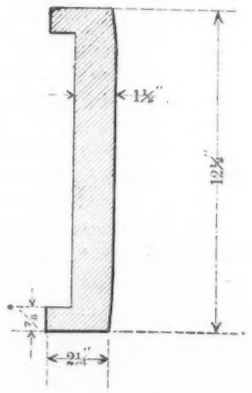


FIG. 2

The only other damage to the engine, apart from the general wrecking of the valve-gear already referred to, was to one of the studs of the steam chest cover-plate (*B*, Fig. 3) being sheared off flush with the plate, and to the corner of the cover, in

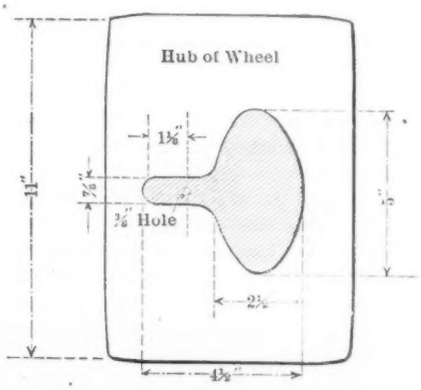


FIG. 4

between the moment that the governor broke and the bursting of the wheel, and as to whether the wheel was flawed. Both engineers agree in estimating the time from the first abnormal sound of the engine to the crash of the wheel as a few seconds only.

Nearly all of the stumps of the arms show marred patches on the fractured sur-

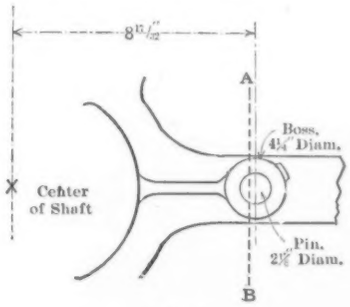


FIG. 5

twenty feet distant, in the same direction as the second hole. The overhead line of 4-inch exhaust-steam piping, connected to the 6-inch riser shown at the right in Fig. 1, was wrecked also.

The engine-room piping, including some rather long stretches, was formerly supported by ceiling hangers, but these had been previously loosened purposely, to prevent the vibration of the piping from shaking the floor above. Owing, perhaps, to the lack of support of these overhead lines, except such as was afforded by the risers of exhaust lines and by the live-steam lines, the shattering and consequent fall of the 4-inch exhaust-steam line brought enough strain on the live-steam riser from the engine cylinder (shown at the left of the middle in Fig. 1) to crack the throttle valve in a complete circle at the point *A*, Fig. 3. The engineer stated that the steam was coming out in a sheet

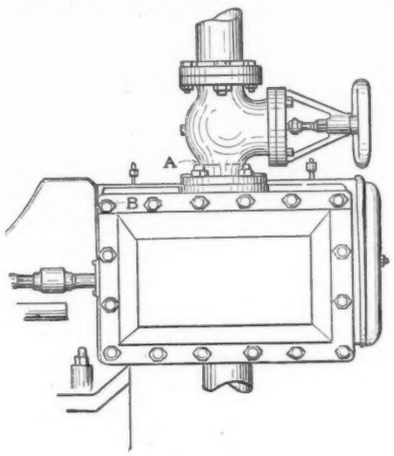


FIG. 3

which was a dent, probably made by the same projectile that sheared the stud. Pieces of the wheel were hurled horizontally in both directions, some of them striking a wall about 60 feet away with considerable force, and another piece carrying away the cylinder lubricator of a small engine nearby, and tearing off the lagging of a brine pipe farther on.

The speed of the wheel when it burst is undetermined. Inquiry of the night engineer, who as already stated was on duty when the accident occurred, of the day engineer, who was on the scene immediately afterward, and of the Government

faces, as if they had been battered with a hard instrument. One expert is reported to regard these as flaws in the casting. It should be stated that the wheel was a "solid" one and that the 2⅛-inch main pin of the governor mechanism passed through one of the arms of the wheel, as shown in Fig. 4, which is a sketch of the actual break, and in Fig. 5, which is a detail sketch of the arrangement as it was before the accident, the latter sketch having been drawn from inspection of the other similar engine. Fig. 4 is a section on the line *AB* of Fig. 5, which is the line of fracture of the arm.

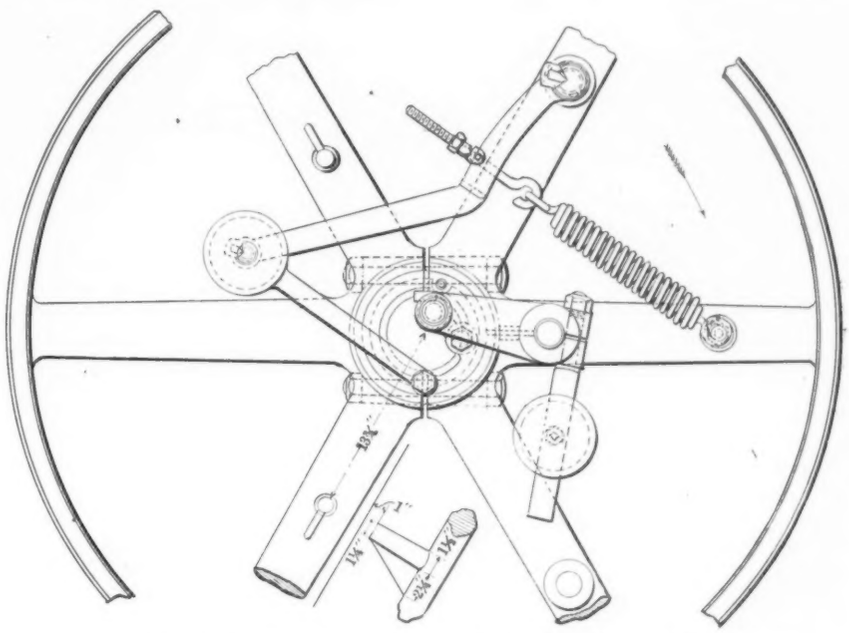


FIG. 6. SHOWING OLD FORM OF "WATERTOWN" GOVERNOR

through this break all around the valve. That this break was due to the strain set up by the wrecking of the overhead piping and not to a blow on the live-steam pipe was evidenced by the fact that the latter bore no marks whatever.

building and boiler inspector, who examined the wreck officially, brought out the usual conflict of opinions. It was agreed that the racing of the engine was the immediate cause of the wreck; but opinions diverge as to the time that elapsed

The break shows a small segment of the hole for the 2⅛-inch pin, passing through the projecting web in Fig. 4 but not indicated in that sketch. The whole of the boss on the outside of the arm was carried way. It was learned that the build-

ing inspector will not make a written report.

Fig. 6 is a reproduction of a drawing of the wheel furnished by the Watertown Engine Company. The governor is of a type that has not been built for ten or twelve years, and the engine is an old one, having been built some fifteen years ago and in constant service much of the time day and night ever since. The governor was very badly worn, so much so that the installation of a new one was considered four or five years ago, at which time the governor was known to be very much out of order and has been repaired more than once by local talent. The Watertown Engine Company, to whom this accident comes as the first of the kind which has ever occurred to their product, is engaged in a thorough investigation in regard to the cause and manner of the accident, and it is possible that their researches may bring forth further interesting material.

Lubrication of Bearings for Steam Turbines

By Edward Russell

There are thousands of bearings carrying shafts running at speeds and temperatures which would have made old-time engineers stare, yet for modern practice are considered quite reasonable and give very little, if any, trouble. Our predecessors did not study the matter very carefully, but relied entirely upon individual experiences; whereas, we can obtain from colleges and professors practically accurate formulas concerning bearings and their lubrication, of which our forefathers took very slight account. In fact, today there are old enginemen driving engines in remote districts where it is the practice to put a piece of tallow on the bearing housing to act as a telltale. If the tallow starts to melt they give the bearing a little attenion, but if it keeps solid they are quite content. Fancy a nice little piece of tallow sliding off of a turbine bearing keep for the simple reason that the temperature of the bearing had reached, say, 140 degrees Fahrenheit.

According to certain articles on turbines which have been published in this country, the surface speed of shafts in the bearings of land turbines is said to be within allowable modern practice when the product of speed $\times$ weight per square inch of bearing surface does not exceed 2500 to 2700. Ordinary practice allows about 50 pounds per square inch of bearing surface with a velocity of 50 feet per second.

It must be borne in mind, in all turbine work in connection with electrical machines, that if the rotors of the latter are fixed electrically central, all the weight of the shaft with its attachments falls on the bottom half of the bearing. In fact, in most turbine work where the bearings are of any size, and in halves, the top is bored out for the entire length, the diameter for an inch or so at each end being made about 1/16 of an inch greater than the diameter of the shaft. Of course, this varies with different makers.

According to some authorities, the amount of oil required for a turbine bearing under ordinary conditions is 0.05 gallon per square inch of bearing surface per minute, the pressure and speed being within the limits mentioned. Take for example the bearings of two large turbines, with rotors weighing 17 tons each, the bearings 11 inches diameter by 32 inches long. One-half inch of the length might be left out of consideration, as the shaft never touches the radius. The speed of each turbine is 1000 revolutions per minute. The maximum quantity of oil allowed per minute to supply the two turbines and the two generators, the thrust-bearings and the governor-gear (which was supplied by a ½-inch pipe) was 33 gallons. The bearings were lined with white metal, the top halves being bored 1/16 inch larger than the diameter of the shaft, except for a distance of 1 inch at each end. The bottom halves were water-jacketed.

The oil was fed through the center of the bottom half of each bearing, this half having a channel cut in its circumference, at the middle of the bearing surface, 2 inches wide, and another running along the bottom of the bearing, to within three inches of each end, one inch wide, which, of course, is lost bearing surface. The top half is nearly 0.0001 of an inch clear of the shaft at each end, with a small hole drilled in the center communicating with a gage and test-cock fixed on to the bearing housing. Under ordinary working conditions there would not be sufficient pressure on the gages to permit a reading, but there would be a steady stream from the test-cock.

Let us examine the bearings, considering each as having an effective length of 31½ inches and a circumferential bearing surface of 17.27 — 2 inches on each side of the bearing. This gives 13.27 inches, and deducting the areas of the channels leaves an actual bearing surface of 375.5 square inches. The weight on each bearing is 19,040 pounds, or 50.7 pounds per square inch of bearing area. The surface velocity of the shaft is 40.8 feet per second. This gives $40.8 \times 50.7 = 2068.56$ pounds, as against the limit of 2500 to 2700 referred to.

Next consider the lubricator. The thrust-block always received nearly half as much more oil than the bearing, so we will consider the thrust-bearing and the governor-gear as two bearings. This is equal to six bearings, which take 5.5 gallons per bearing, while according to the prescribed data these bearings should receive 18.7 gallons per minute, if their speed pressure equals between 2500 and 2700; but in this case it only comes to 2068.56. Even then, it does not appear clear why they should be so much below the quantity assumed by the data given. The data state nothing concerning the rise in temperature of the oil.

This machine has been run on 27 gallons of oil per minute, i. e., 4.5 gallons per bearing per minute with an average temperature rise above the temperature of the engine room of 55 degrees Fahrenheit, entering the bearing at 95 degrees and leaving it at 135 degrees, the water being shut off of the bottom halves at the time. This indicates that 0.02 gallon per square inch of bearing surface is quite sufficient as the rise in temperature is not harmful, and the makers of good turbine oil will guarantee its working up to 175 degrees Fahrenheit.

The machines have been run with much less oil than stated, but the mentioned quantity gave perfect satisfaction. In the ordinary course of running these machines get a much larger quantity than they require, owing to the station people preferring to keep the oil in motion to prevent settlement in the header pipe. In the case cited the oil is supplied by a central gravity-feed system and looked after quite independently of the turbines.

The Westinghouse Receivership

The industrial world has been jarred since the issuance of our last number by the application for the appointment of receivers for the Westinghouse Electric and Manufacturing Company, the Westinghouse Machine Company and the Nernst Lamp Company. The receivers have found that the trouble was not a falling-off of business, but was brought about by the state of the money market. Large orders covering work which must extend over periods of months and sometimes years before returns and profits could be realized required the employment of borrowed capital, and the great stringency of the money market prevented the obtaining of ready money from the customary sources. There is a large demand for the products of all three companies, they are excellently equipped for meeting this demand, there has not been any hitch in their operations, and there is no question that the properties will be returned to the stockholders unimpaired in value as soon as the money market resumes its normal condition.

President Roosevelt has called a conference of the governors of all the States to consider to what extent the natural resources of the country can be conserved for and restored to the people.

Test of a 1000-kilowatt Turbine-generator Unit

A test was recently made of the Allis-Chalmers turbine-generator unit installed at Kokomo, Ind., in the power house of the Kokomo, Marion & Western Traction Company, for the purpose of determining the steam consumption under normal load. The unit comprises an Allis-Chalmers Parsons standard horizontal turbine and a standard Allis-Chalmers turbo-alternator, directly coupled. The condensing apparatus is of the Allis-Chalmers standard turbo-jet type. The characteristics of the unit are as follows:

Rated capacity, 1000 kilowatts; speed, 1300 revolutions per minute; frequency, 60 cycles; winding, two-phase; e.m.f., 2300 volts; current per phase (normal), 218 amperes.

The turbine was built to operate normally with steam pressure of 140 pounds per square inch gage pressure at the turbine throttle, dry saturated, and a vacuum of 28 inches, referred to 30 inches barometer at the exhaust nozzle. The unit is calculated to carry an overload of 50 per cent. when operating under the above steam conditions and at 100 per cent. power factor.

The auxiliary machinery consists of a motor-driven exciter, a steam-driven exciter, the jet condenser and pump mentioned, and two small circulating pumps. There are five boilers supplying steam to a loop header. The turbine, two Russell engines and an auxiliary header are supplied from this main header.

During this test boilers 3, 4 and 5 were made to supply steam to the turbine being tested. Both sets of boilers were operated at as nearly the same steam pressure as possible. The water delivered to the three boilers was weighed in calibrated barrels. The drip from the steam header and from the separators at the Russell engines and at the throttle of the turbine was collected and weighed.

At the conclusion of this efficiency test, the three boilers were cut out of service and the entire load of the station was thrown on boilers 1 and 2. With the plant thus operated, enough fire was allowed to remain under boilers 3, 4 and 5 to maintain a steam pressure equal to that carried by 1 and 2. The weight of water fed to 3, 4 and 5 during this test was assumed to establish a rate of leakage and radiation from the boilers and piping which would apply to the efficiency test.

In determining the steam consumed by the turbine, the drip caught at the Russell engines, the steam-header trap, and the separator at the turbine throttle, and the amount due to leakage and radiation in the boiler, as shown by the leakage test, were subtracted from the water fed to the boilers. This result corrected for the quality of the steam was assumed to equal the dry steam supplied to the turbine. The electrical output was measured by carefully calibrated instruments. All the load it was possible to give to the turbine aggregated only a little over one-half its normal capacity.

Following are the results of the test:

Average load—553.3 kilowatts.

Per cent. of rated load—55.33.

Duration of test—4 hours.

Steam pressure at turbine throttle—136.4 gage.

Steam pressure at turbine inlet—61.2 gage.

Vacuum turbine exhaust—26.59 inches.

Barometer—28.93.

Vacuum at turbine referred to 30 inches barometer—27.66.

Revolutions per minute—1800.

Total water used—55,662 pounds.

Total drip—450.6.

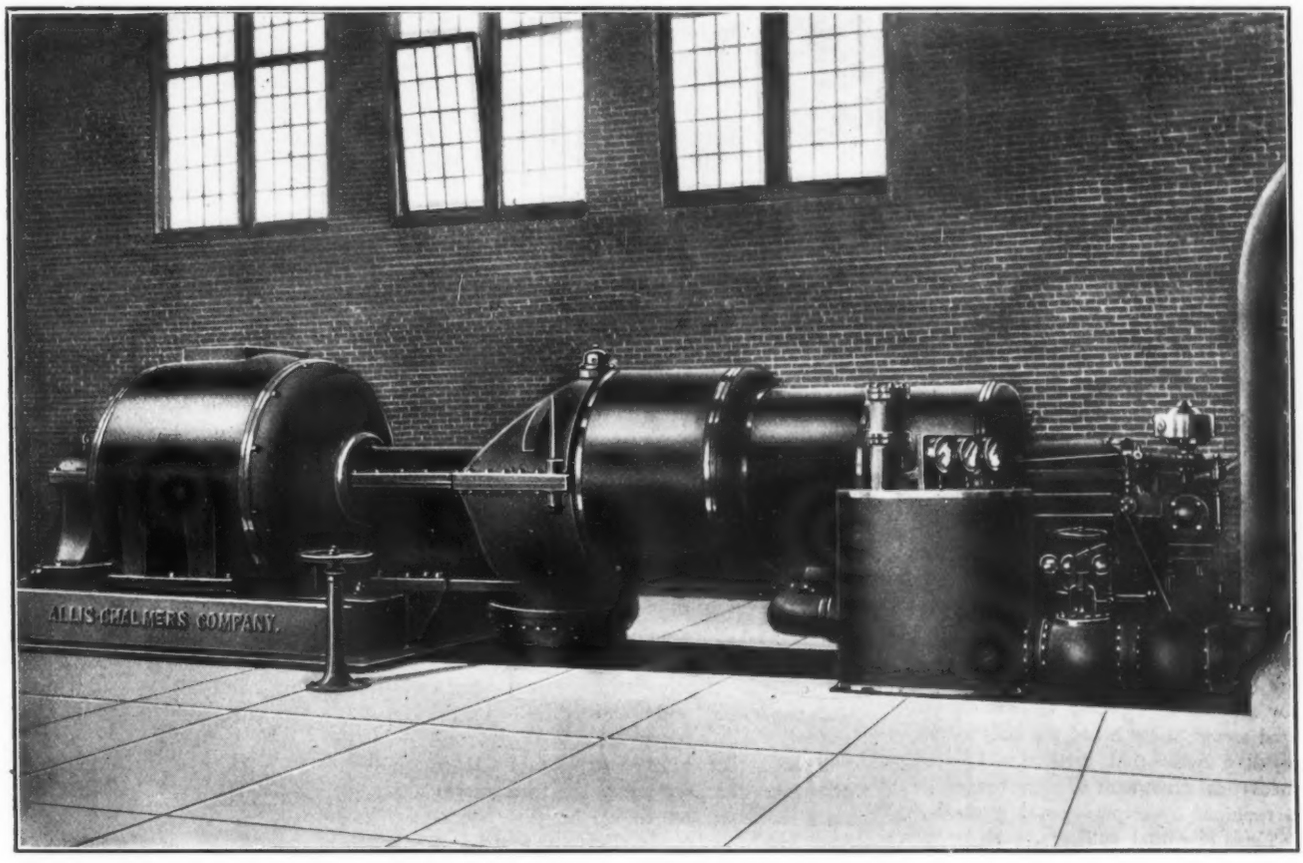
Boiler leakage—5344.6 pounds.

Moisture in steam by calorimeter—2.82 per cent.

Dry steam supplied to turbine per hour—12,115 pounds.

Actual consumption of dry steam per kilowatt-hour—21.90 pounds.

The guaranteed steam consumption for one-half load with 28 inches vacuum was 24 pounds per kilowatt-hour, and the result of the test showed that the actual steam consumption was 2.1 pounds less than the guarantee.



TURBO-GENERATOR IN KOKOMO, MARION AND WESTON TRACTION COMPANY'S PLANT

Book Reviews

MODERN STEAM ENGINEERING. By Gardner D. Hiscox. Published by the Norman W. Henley Company, New York, 1906. Cloth; 487 pages, 6x9 inches; 405 illustrations. Price, $3.

Like all of Mr. Hiscox's other books, this one is ambitious in scope and not quite satisfactory in execution. His scheme is excellent, and if he had taken the precaution to lay out the scheme and then intrust its execution to a careful and thoroughly equipped engineer, the result would have been fine. It would have been a good idea also to give credit to all of the various sources whence data and tabulated matter were obtained.

The book contains illustrations of many types of apparatus and is therefore convenient for reference as to general construction. It contains many inaccuracies, however, so that one should scrutinize closely any figures or technical statements taken from it.

THERMODYNAMICS OF THE STEAM ENGINE AND OTHER HEAT ENGINES. By Cecil H. Peabody. Fifth edition, rewritten. Published by John Wiley & Sons, New York. Cloth; vii + 533 pages, illustrated by 117 figures. Price, $5.

In this revision of the well-known work of the author, who has been for many years connected with the faculty of the Massachusetts Institute of Technology, the amount of theoretical work has been reduced and the matter has been so arranged that the general thermodynamic method (Chapter IV) can be omitted at first reading, or all together if preferred; in which case direct special derivations are given of the ratio of specific heat for air and the specific volume for saturated steam, these being the only items depending upon that method. The entire theoretical treatment of superheated steam is replaced by experimental methods.

The individual subjects, such as steam engines, gas engines, compressed air, refrigerating machines, etc., are made independent, so that they may be read in any order, or so that either is available for reference without being confused with another. To some extent the several chapters on steam engines are treated in the same way.

New experimental matter by Callendan, Bonner, Knoblauch and Thomas, concerning the absolute temperature, specific heat of water, specific volume of steam and specific heat of superheated steam, have been used throughout the book and in the computation of the tables.

Considerable attention has been given to the temperature-entropy diagram as a method of illustration and a diagram for approximate determination is given, which is clearer than others of the same type. The treatment of entropy has been made more plain and practical and the limitations of the use of the diagram pointed out.

The chapter on Internal-combustion Engines has been enlarged to cover modern practice, and some idea is given of probable expansion in that line of engineering.

A chapter is devoted to the Steam Turbine, with a direct and simple method of making calculations by means of the temperature-entropy diagram.

The tables of the physical properties of steam and other vapors, by the same author, have been revised contemporaneously with the larger work and will appear in the revised form practically at the same time. They have been entirely re-calculated, using the data referred to above. They will give the entropy of vaporization, but otherwise will be in the old form which has proved to be very convenient. The greatest advance will be the temperature-entropy tables which will allow one to solve problems in adiabatic expansion, and in expansion modified from the adiabatic, in the same way that he looks up areas and circumferences of circles.

TECHNISCHE UNTERSUCHUNGSMETHODEN ZUR BETRIEBSKONTROLLE, INSBESONDERE ZUR KONTROLLE DES DAMPFBETRIEBES; ZUGLEICH EIN LEITFADEN FUER DIE ARBEITEN IN DEN MASCHINENBAULABORATORIEN TECHNISCHER LEHRANSTALTEN. By Julius Brand. Second enlarged and improved edition. Published by Julius Springer, Berlin. Cloth; 411 pages, 6x9⅛ inches, with 301 figures in the text, two lithographed plates and numerous tables. Price, 8 marks.

This is a book which, though of most value to the mechanical engineer concerned with the testing of steam plants, and professors and students in technical colleges, will also be found by the intelligent steam engineer to contain a store of information regarding the instruments and processes employed in this work. The first chapter, treating of fuels and the theory of combustion, is followed by a long one on flue-gas analysis, describing the various forms of apparatus for this purpose, and tells how to calculate the excess of air from the results of the analysis; then come several pages full of equations and chemical formulas, pertaining to the determination of the heat lost in the waste gases. The subject of fuel calorimetry is next taken up, solid, gaseous and liquid fuels being considered in turn; it includes descriptions of various kinds of calorimeters and the methods of calculation, influence of and determination of moisture, and the procedure in taking samples. There is a short section on the density of smoke. Instruments for measuring temperatures and differences of pressure are then described, followed by the various kinds of polar planimeter, with the theory, method of use, and testing of this instrument. The importance of the steam-engine indicator is recognized by the devoting of 86 pages to this subject, with 97 illustrations; the indicators shown are mostly European, and include continuous-diagram, "optical" and integrating indicators; reducing motions, practical use, testing and calibration of the indicator, complete the chapter. It it interesting to note that the author includes the "torsion indicator" used for determining the horse-power of steam turbines by the torsional deflection of the shaft.

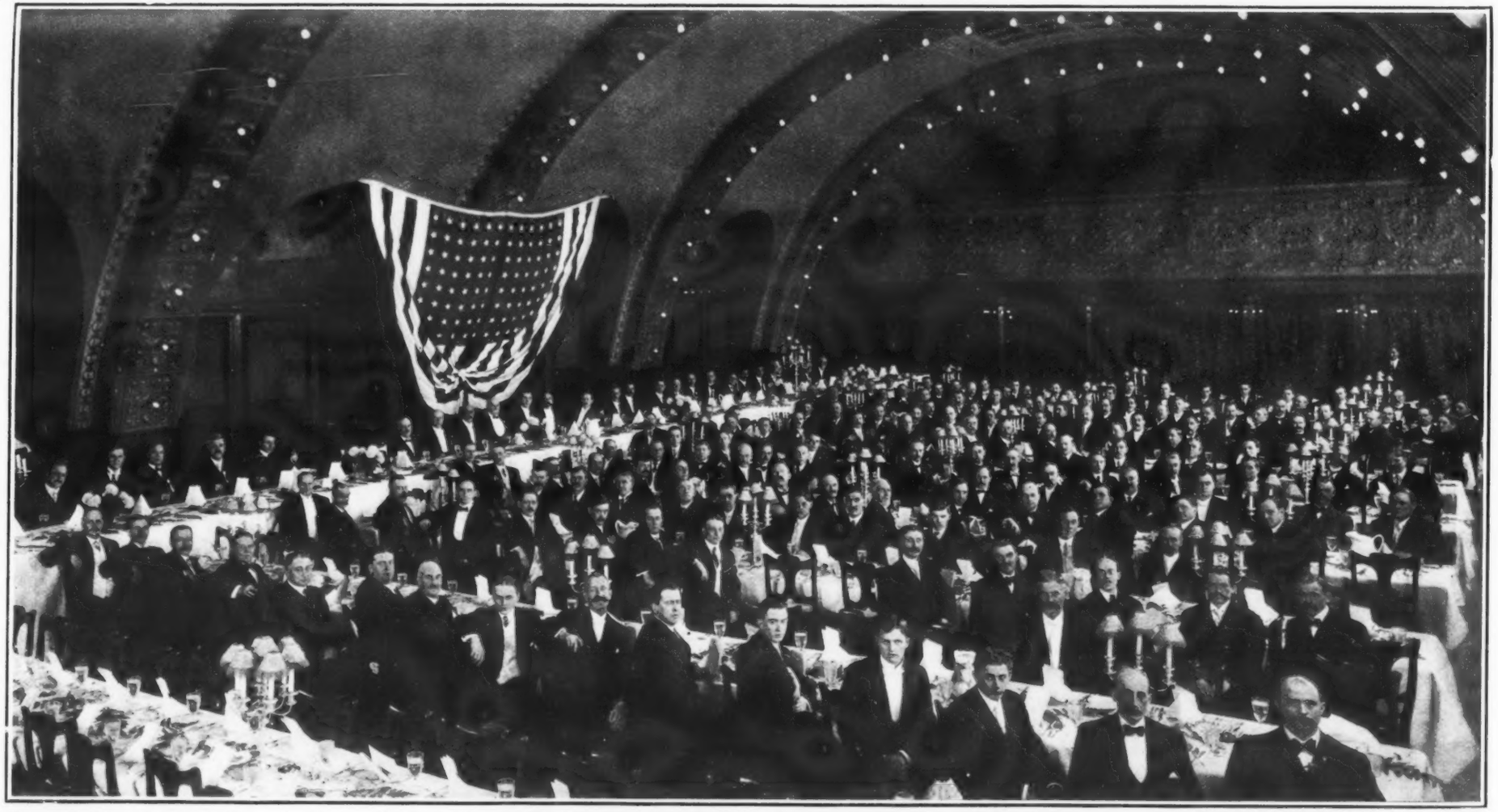
The next important section of the book treats of efficiency tests of steam boilers and engines, in which the technique of engine indicating is gone into more fully, with illustrations of defective diagrams and explanations of the causes of the defects; explanation of the combining and working up of the cards, etc. As examples, there are the complete data of two actual tests, one on a compound non-condensing engine, and the other a guarantee test on a plant of considerable refinement, including a 3000-horse-power triple-expansion engine, water-tube boilers, and auxiliary apparatus; the records of the calibration of the instruments, test readings, etc., are all given at length. The book concludes with a chapter on the methods of examining lubricating oils. It is evident that much care was taken to produce this book with first-class typography, illustrations, etc. As an example, a table of products of planimeter readings multiplied by the planimeter constant is duplicated, the duplicate being printed on one side of the paper and perforated for removal from the book for ready reference. One of the folding plates, illustrating the combining of indicator diagrams by the use of cross-section paper, is actually printed on a red and blue "Liniennetz." A comprehensive table of factors of evaporation is also given.

Books Received

"Refrigeration, Ice Making and Refrigeration Machinery." By W. H. Wakeman. The American Industrial Publishing Company, Bridgeport, Conn. Paper; 43 pages, 6x9 inches; 15 illustrations. Price 25 cents.

"Railroad Men's Catechism." By Angus Sinclair. Angus Sinclair Publishing Company, New York. Cloth; 200 pages, 4x6½ inches; indexed; illustrated. Price $1.

"Superheat, Superheating and Their Control." By William H. Booth. D. Van Nostrand Company, New York. Cloth; 155 pages, 5¾x9 inches; 27 illustrations. Price $1.50.



The subordinate associations of the National Association of Stationary Engineers, located at Chicago, united in holding a banquet at the Auditorium on Saturday evening, October 26, to celebrate the completion of the first quarter century of the existence of the association. Between 200 and 300 engineers in charge of the largest plants in the city assembled about the tables. John McGrath acted as toastmaster, and introduced the several speakers with apt remarks; George N. Carmen, director of the Lewis Institute, discussed the "Trend of Technical Training;" National President Joseph F. Carney, of New York, was to have had the theme, "Our Position in the Industrial World," but was unable to be present and was represented by ex-Treasurer Clare F. Wilson; James G. Beckerleg, the second president of the association, reviewed the work of the association from the first convention which he attended in 1882 up to the present; John W. Lane, editor of the *National Engineer*, the organ of the association, spoke to the "Mechanical Press;" Charles W. Naylor, consulting engineer for Marshall, Field & Co., described the difference between "The Engineer of 1882 and Now;" Fred W. Raven, national secretary, gave some interesting "Statistics" concerning the growth and development of the organization; Alfred Johnson, chief engineer for Manville Brothers, considered the "Duties of the Members of the Association;" R. D. Tomlinson, condenser engineer, of the Allis-Chalmers Company, and past president of the organization, spoke upon the "Progress of the Engineer." A poem entitled "Liberty," written by Thomas Mason, was read by Leander Haynes. George M. Cowan, superintendent engineer for the Congress Hotel Company, made a happy response to an invitation to speak. There were five past national presidents, three past national secretaries and three past national treasurers present

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Regulation of Series Incandescent Circuits

We have a circuit of twenty-two 50-candle-power incandescent lamps in series supplied from a 2300-volt alternating-current circuit. (a) What is the best simple method of keeping the circuit closed and the current normal when a lamp filament gives out? (b) The line wire is No. 8, but each lamp is connected to the main line with No. 14 leads; are these heavy enough?

H. S. W.

(a) There is no simple and inexpensive method that is actually reliable. The simplest method is to use a shunt cut-out at each lamp, consisting of a very thin disk of paper held between two springs, the springs being connected to the terminals of the lamp. The most reliable method is to connect an electromagnet in shunt to the lamp and arrange its armature to release a gravity cut-out when drawn toward the magnet poles.

(b) Electrically, yes. Mechanically, it is rather slender; No. 12 is preferable.

To Determine Angle of Miter-box Grooves

It is required to make a miter box in which to cut molding to fit around a post the cross-section of which has the shape of a regular decagon. Determine the angle that the saw must make with the side of the box

K. J.

As the circle would be divided into 10 equal parts the smaller angle of each of the sectors (see Fig. 1) would be $360 \div 10 = 36$ degrees. As the sum of the three angles of a triangle is 180 degrees the sum of the other two angles would be $180 - 36 = 144$ degrees, and as they are equal each would be one-half of this, or 72 degrees.

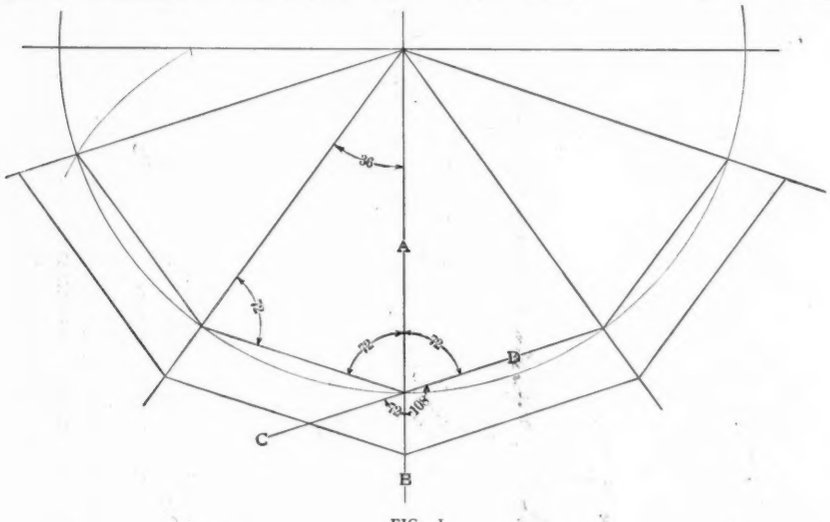


FIG. 1

When two straight lines cross each other the opposite angles formed are equal. In Fig. 2, for example, the angle A equals the angle B; and the angle C equals the angle D.

Then when the line $A\,B$ in Fig. 1 crosses

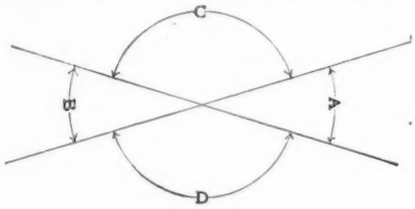


FIG. 2

the line $C\,D$, the angle between B and C must be 72 degrees, and the angle between B and B the rest of the half circle, or $180 - 72 = 108$ degrees.

Gas-engine Regulation

Why is throttling regulation used on large gas engines if it is so uneconomical for steam engines?

H. T. N.

The cases are not exactly parallel. Each gas-engine charge, no matter how small, is expanded as far as the cylinder proportions allow, whereas a throttling steam engine derives no energy from the steam by expanding it.

Economy in Expansion

Why is it more economical to cut off the admission of steam early in the stroke of an engine than to reduce its pressure b throttling, the work done in both cases being equal?

H. T. N.

Because, with the cut-off a large part of the energy applied to the piston is derived from the expansion of the steam, whereas the throttling engine does not utilize the expansive property of the steam. A cylinder of one cubic foot capacity, for example, taking steam at 85 pounds gage pressure and cutting off at quarter stroke, will take one-fourth cubic foot of steam per stroke, ignoring clearance; the steam will have a mean forward pressure of 45 pounds. To get the same pressure by throttling, the steam must be throttled to 45 pounds gage pressure, and a cubic foot must be taken in the cylinder. One cubic foot at 45 pounds weighs 0.1422 pound, while ¼ cubic foot at 85 pounds weighs only 0.0574 pound, or less than one-half as much.

What a "Storage" Battery Does

How does a storage battery store up electricity if electricity is not ponderable or tangible?

K. T. S.

It does not literally store electricity. When a current is passed through the battery it produces certain chemical changes in the "active material" on the plates, and these changes produce a difference of electrical potential between the opposing plate surfaces. When the difference of potential is as high as it can be carried, the battery is said to be "charged." Now, if the opposing plates be connected by a metallic conductor, forming an external circuit, the difference of potential between the plates will cause an electric current to flow through the completed circuit; this flow is opposite to the direction of the charging current, and it therefore has the reverse, or discharging effect on the plates, which will be gradually brought back to their original chemical condition if the discharge current be allowed to flow long enough.

To Find the Diameter and Length of a Cylinder

The volume of a cylinder is 11.78 cubic feet. If the length of the cylinder is 2½ times the diameter, what are (1) the diameter, and (2) the length. K. J.

The area is 0.7854 times the square of the diameter, or area $= 0.7854\ D^2$. Then the area divided by 0.7854 equals the square of the diameter.

$$D^2 = \frac{Area}{0.7854} = \frac{148.49}{0.7854} = 189.0629,$$

and the square root of this equals the diameter.

```
189.0629  ( 13.750   outside diameter
1           12.875   inside diameter
---         -----
20 ) 89      0.855   thickness
23 ) 69
---
260 ) 2006
267 ) 1869
-----
27405  13729
       13725
```

Volume = area × length
Area $= 0.7854\ D^2$
Length $= 2.5\ D$
Volume = 11.78 cu.ft. = 20355.84 cu.in.
Volume = area × length
$20355.84 = 0.7854\ D^2 \times 2.5\ D$
$20355.84 = 1.9635 \times D^3$

$$\frac{20355.84}{1.96305} = D^3$$

$$D = \sqrt[3]{\frac{20355.84}{1.96305}}\quad 10369.5 = 21.8 \text{ inches.}$$

Since the length is 2½ times the diameter, the length is $2\frac{1}{2} \times 21.8 = 54.50$ square inches.

Engineering Societies

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President, Frederick W. Hutton, New York, N. Y.; sec., Calvin W. Rice, Engineering building, 29 West 39th St., New York. Next meeting, New York, December, 1907.

ENGINEERS' CLUB OF PHILADELPHIA

Pres., Henry W. Quimby; sec., Walter L. Webb; house, 1122 Girard St.; regular meetings 1st and 3d Saturdays.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Navy Dept., Washington, D. C. Pres., B. C. Bryan, Commander, U. S. N.; sec. and treas., Theo. C. Fenton, Commander, U .S. N.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., M. F. Cole, Newman, Ga.; sec., J. D. Farasey, Cleveland, O. Next meeting, Atlantic City, N. J., fall of 1908.

WESTERN SOCIETY OF ENGINEERS

Pres., W. L .Abbott; sec., J. H. Warder, 1737 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., S. M. Kintner; sec., Edmund Yardley, Pittsburg, Pa. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Arthur Williams, New York; sec. and treas., W. C. L. Eglin, Philadelphia. Association headquarters, 136 Liberty St., New York.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dr. Samuel Sheldon; sec., Ralph W. Pope, 95 Liberty St., New York. Meetings monthly excepting July and August.

ENGINE BUILDERS' ASSOCIATION OF THE UNITED STATES

Pres., A. L. Merriam, Oswego, N. Y.; sec., C. H. Sembower, Reading, Pa.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John L. O'Brien, Chicago, Ill.; sec., W. J. Ranton, 108 Powers Bldg., Rochester, N. Y. Next meeting, Put-in-Bay, Ohio, August, 1908.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Joseph F. Carney, New York; sec., F. W. Raven, 525 Manhattan building, Chicago, Ill. Next convention, Denver, Colo., September, 1908.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., A. J. Dietrich, Baltimore, Md.; Supr. Cor. Engr., Frederick Markoe, 931 N. Orianna St., Philadelphia, Pa. Next convention, Baltimore, June, 1908.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Pres., F. W. Ballard; sec., W. A. Rowe, Cleveland, O.

MASTER STEAM BOILER MAKERS' ASSOCIATION

Pres., J. H. Smyth; sec., Geo. M. Clark, 1337 N. Maplewood Ave., Chicago, Ill.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, Peoria, Ill. Next convention, Philadelphia, September, 1908.

Personal

William F. M. Goss, who, as dean of the Purdue University, Lafayette, Ind., has made a reputation which is world-wide, has accepted the position of dean of the college of engineering and school of railway engineering and administration of the University of Illinois.

W. Edgar Reed, electrical engineer, who was formerly associated with the Westinghouse companies, at East Pittsburg, Penn., and at Paris and Havre, France, has opened an office for general consulting work in the Machesney building, Pittsburg, Penn. Mr. Reed is a member of the American Institute of Electrical Engineers and the Engineers' Society of Western Pennsylvania.

Obituary

W. S. Whiting, incorporator and former president of the Brown-Corliss Engine Company, Corliss, Wis., died October 31, as the result of being run over by a train on the Chicago, Milwaukee & St. Paul railroad.

Thomas Hilton Williams, president of the A. A. Griffing Iron Company and of the E. A. Williams Brass Foundry, of Jersey City, died October 19, after a lingering illness, at the age of 59 years. He was a member of the American Society of Mechanical Engineers and of the Engineers' Club.

"The Economical Heating of Water and Air in Breweries and Malt Houses" is the subject of a 16-page booklet recently issued by the Green Fuel Economizer Company, of Matteawan, N. Y. The first seven pages of the booklet are devoted to a reprint of an article by Herr C. Eberle, of Munich, on "The Influence of Boiling by Steam on the Boiler Plants of Breweries," in which it is shown that the highest economy is reached only when both the exhaust steam from the different machines about the brewery and the waste gases from the boiler furnace are utilized for producing hot water. An example is fully worked out with diagrams and layout of machinery to show this. The second part of the pamphlet takes up the use of warm or cold and moistened air for promoting germination, and of the use of hot dry air in the malt kiln. By utilizing blowers to move this air, much quicker and better results may be obtained than by methods relying upon natural draft. It is also possible to run the plant to full capacity at all times of the year, and in all conditions of the weather.

The next annual meeting of the Marine Engineers' Benevolent Association will be held at Washington, D. C., January 20 to 25, inclusive.

Allis Mutual Aid Society

The recurrence of the annual ball of the Allis Mutual Aid Society, which took place at Milwaukee on October 26, makes pertinent brief mention of what this feature of the Allis-Chalmers works is and how it came to be. It was organized in 1883, during the time of Edward P. Allis & Co., and grew out of a small balance left over from a sum which had been devoted to a house-warming and banquet on the occasion of the completion of the company's new carpenter shop. The management and employees got together and agreed to contribute mutually to a fund to be devoted to the relief of employees who might become injured, sick or otherwise in need. Three hundred employees were at once enrolled as charter members of what is now an immense society.

An initiation fee of 50 cents is charged and the dues are three dollars per annum. To this the company yearly contributes thousands of dollars. The only other source of income is through entertainments. With the funds thus provided ambulances, hospital beds, operating tables and instruments for rendering first aid to the injured are maintained; there are a sick benefit of fifteen dollars a month, and a death benefit of one hundred dollars.

The officers of the society are: President, Edward Reynolds; vice-president, Henry Freeman; secretary, Thomas A. Callahan; treasurer, Charles Allis.

The I. C. S. Fraternity

Recently there was organized at Scranton, Penn., an unique society to which all the students of the International Correspondence Schools, past, present and to come, will be admitted to membership, with consent of President T. J. Foster and his coadjutors, upon expressing a desire to participate in the closer social and intellectual fellowship made possible by such association. It is called the I. C. S. Fraternity. There will be chapters formed wherever practicable the world over, and a member of one chapter will be entitled to a seat in any other chapter. Each chapter will have a library and reading room and, where possible, there will be rooms for social diversions. Indoor and outdoor athletics will be cultivated where conditions are favorable, also. There will be a registrar to every chapter whose time will be devoted to encouraging, guiding and aiding students. Every month an educational session will be held. It will also be the duty of each chapter to render aid to any member, whether educationally, industrially or financially, and the sick will be visited and tended as in all fraternal organizations.

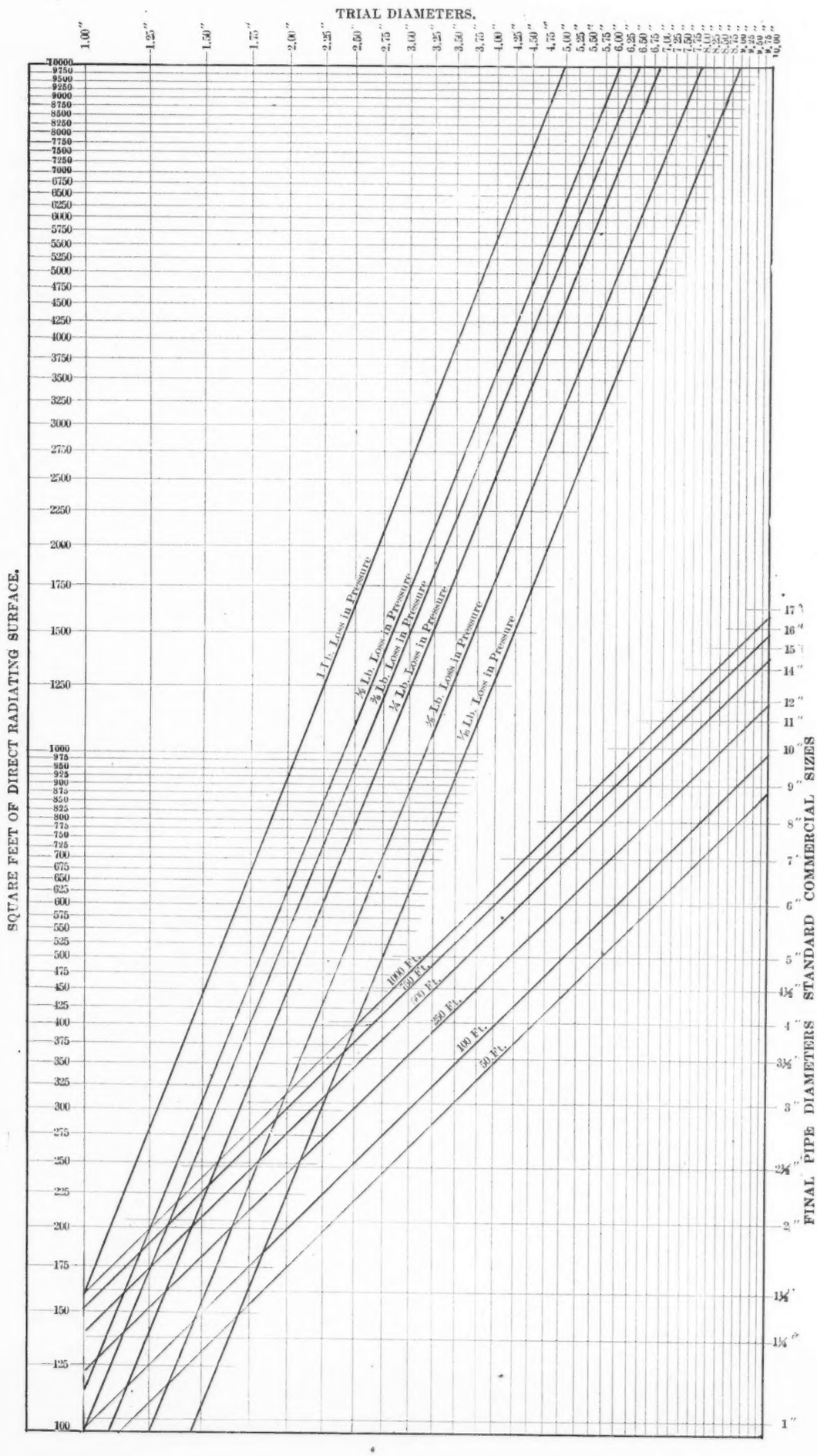


Diagram for Determining Pipe Size for Radiating Surface

Follow the horizontal indicating Square Feet of Radiating Surface to its intersection with the long diagonal indicating the allowable Loss in Pressure. Drop vertically to the intersection of the shorter diagonal indicating Length of Pipe, and follow horizontally to the pipe Diameter in the right-hand column.

Diagram for Determining Pipe Size for Radiating Surface

The diagram on the opposite page has been plotted by the engineering department of the All-Metal Valve Company, of New York, for use in determining the commercial size of pipe necessary to supply direct radiation at various distances, and various allowable losses in pressure.

The figures on the left-hand margin of the diagram represent square feet of direct radiation. Those on the right the commercial diameters of standard-weight pipe. The vertical lines marked "Trial Diameters," on the upper margin of the diagram, are intended for use in cases where extreme refinement is called for.

The long diagonals represent the various losses in pressure in pounds per square inch, and the short diagonals on the lower part of the diagram the various distances in feet. The amount of direct radiation to be supplied, and the distance of such radiation from the source of supply being known, the desired loss of pressure is assumed, and the size of pipe necessary is determined as follows: Find the intersection of the horizontal line, representing square feet of direct radiation, with the long diagonal line, representing the assumed loss. Follow this intersection vertically downward until the short diagonal, representing the distance, is met; from that point move horizontally to the right, and in the right-hand margin find the nearest commercial size of pipe necessary.

Example

Direct radiation = 2200 square feet.

Distance = 50 feet.

Desired drop in pressure = ⅜ pound.

Find the intersection of 2200 with the diagonal representing ⅜-pound loss. Follow down vertically to the 50-foot distance diagonal, and from the new point of intersection follow horizontally to the right-hand margin. The nearest pipe size is 3 inches.

Where the pipe supplying the radiation contains a large number of fittings, or other conditions make such a refinement necessary, it is advisable to add to the actual distance of the radiation from the source of supply a distance equivalent to the resistance offered by the fittings, the value of which, expressed in feet of pipe of the same diameter as the fitting, will be found in the accompanying table. Where the size of pipe is to be found in such a case, the size of fittings to be allowed for should be determined from the trial diameters on the top of the diagram. That is, having found the intersection of the radiation line with the desired loss diagonal, follow up vertically and the nearest pipe diameter will be the one which should be used in determining the revised distance to be used in the final operation.

Example

If in the above example the pipe supplying the radiation contained three elbows and a globe valve, we would proceed as follows: Find the intersection of 2200 with ⅜-pound loss diagonal, as before. Follow upward and find the trial diameter, in this case 3½ inches. In the table it will be found that three 3½-inch elbows are squal to 35 feet of pipe; one 3½-inch globe valve 25 feet 4 inches, say 25 feet, of pipe; and as there are three elbows, one valve and the entrance to the radiating system or unit, there will be five 3½-inch entrances in all, which is equal, according to the table, to about 86 feet. The resistance offered by the fittings and valve will, therefore, be equal to 35 + 25 + 86 = 146 feet. Add to this the actual length of the piping, 50 feet, and we have for our revised distance, allowing for the fittings, 196 feet. Now, finding the original intersection of the 2200 with the ⅜-pound loss diagonal, follow downward to the nearest distance diagonal to 196 feet, which in this case is 250 feet. From the intersection thus found, follow horizontally to the right and in the left-hand margin of the diagram read the actual commercial size required—very nearly 4 inches, but since the distance used was considerably above that actually required, 4 inches should be sufficient.

In the above examples, it has been assumed that the diameter is the unknown quantity, but, of course, if other factors than those assumed in the above example are known, the unknown quantity, whether it be radiation, loss in pressure or distance, can be readily found by proper use of the diagram.

FEET OF PIPE TO BE ADDED FOR EACH FITTING.

	1"	1¼"	1½"	2"	2½"	3"	3½"	4"	4½"	5"	6"	7"	8"	9"	10"
Elbows..	3'-4"	4'-2"	5'-0"	6'-8"	8'-4"	10'-0"	11'-8"	13'-4"	15'-0"	16'-8"	20'-0"	23'-4"	26'-8"	30'-0"	33'-4"
Globe V.	6'-8"	8'-4"	10'-0"	13'-4"	16'-8"	20'-0"	23'-4"	26'-8"	30'-0"	33'-4"	40'-0"	46'-8"	53'-4"	60'-0"	66'-8"
Entrance	5'-0"	6'-3"	7'-6"	10'-0"	12'-6"	15'-0"	17'-6"	20'-0"	22'-6"	25'-0"	30'-0"	35'-0"	40'-0"	45'-0"	50'-0"

Objection has been made to the drop-by-drop system of oiling on the ground that it tends to niggardliness in the supply of oil, and actually induces waste, since the oil is liable to be burned and practically useless after going once through the bearing. For surfaces working under severe conditions the forced oil system may be used to good advantage, but has the disadvantage of dependence upon a pump.

Business Items

The Potter Separator Company, Newburgh, N. Y., is sending out a very neat and handy ten-year calendar.

The Ball Engine Company has opened a sales office at 1001 Arcade building, Philadelphia, under the management of H. P. Penfield.

The General Electric Company has been awarded two gold medals and a bronze medal on account of its exhibit at the Jamestown Exposition.

The Allis-Chalmers Company, of Milwaukee, has been awarded the gold medal for electric generators and motors, exhibited at the Jamestown Exposition.

A large wall calendar for 1908 including a sheet for December, 1907, is being distributed by H. B. Underwood & Company, 1021 Hamilton street, Philadelphia, Penn.

Charles A. Schieren & Company have been awarded the gold medal at the Jamestown Exposition for the superiority of their "Duxbak" waterproof and "Duxbak" steam-proof leather belting.

The Wisconsin Engine Company, of Corliss, Wis., has been awarded a contract for three engines for the Spanish-American Iron Company, of Cuba, a subsidiary of the Pennsylvania Steel Company.

H. M. Underwood, with offices at 3 Park Row, New York, has been appointed the New York representative of the Safety Equipment Manufacturing Company, of Chicago, which makes the Gould feed-water regulator.

The Ridgway Dynamo and Engine Company, of Ridgway, Penn., has reopened its Chicago sales office at 824 Marquette building. F. S. Hickok, who has had extensive experience in electrical and power-plant fields, is in charge as manager.

If you are interested in friction clutches a very complete description of the Johnson friction clutch is given in the 1908 catalog just issued by the Carlyle Johnson Machine Company, Hartford, Conn. The clutch has very few parts and great claims are made for it.

When John Wanamaker built his new store in New York City, the Pittsburgh Gage and Supply Company, of Pittsburg, equipped his power plant with a "White Star" continuous-oiling system. This installation having proved its usefulness, Mr. Wanamaker has just ordered a duplicate system for his Philadelphia store.

The Pittsburgh Gage and Supply Company, Pittsburg, Penn., has just moved into its new seven-story factory, where with unlimited facilities it will be better able than ever to fill orders promptly. It might be said that the new plant is the largest and most complete one of its kind between New York and St. Louis.

William S. Love, who for the past eight years managed the business of the Wheeler Condenser and Engineering Company in the Central West, and who has been in New York for the last year as general office manager, will resume charge of the Chicago office of the company at 1137-8 Monadnock building, January 1, 1908.

The Loew Manufacturing Company, Cleveland, Ohio, has a No. 0 power machine, for cutting and threading ¼- to 2-inch pipe. This machine has been designed principally for pipe-machine users who desire a power-driven machine that will take small sizes and yet do not care to go to the expense of a large lathe-bed outfit.

The Parker Boiler Company, Philadelphia, Penn., recently received an order from the Southern Pacific Company for twelve 645-horse-power boilers and superheaters, to be installed in its new power plant at Oakland, Cal. The company also received an order from the University of Pennsylvania for two 468-horse-power boilers.

The Akron Metallic Gasket Company, Akron, Ohio, will issue a new catalog the first of the year containing a technical treatise on the use of metal gaskets in steam lines. This company also offers to our readers the use of its information department for all matters pertaining to steam, water and gas connections where the use of gaskets is required.

The United Engineering and Foundry Company, Pittsburg plant, has recently installed a 10-ton, 60-foot span electric Northern traveling crane, and the new power station of the Columbia Improvement Company, Seattle, Wash., has installed a 50-ton, 3-motor electric Northern traveling crane, furnished by the Northern Engineering Works, Detroit, Mich.

The B. F. Sturtevant Company, of Hyde Park, Mass., has issued a bulletin descriptive of the steam turbine to which attention was called in our November number. The bulletin illustrates the turbine in parts, and as assembled, gives the dimensions of the standard sizes, etc., and will be interesting and useful to those who desire to keep informed upon what is available in this line.

A somewhat different type of booklet, entitled "From Water to Steam and Some of the Things that Happen On the Way," has been sent to us by the William B. Pierce Company, of Buffalo, N. Y. It is a clever piece of work and its contents will prove of interest to any user of steam boilers. A copy can be obtained by addressing the company at the Jewett building, Buffalo.

The Franklin Filter Company, 306 North Commercial street, St. Louis, Mo., recently received orders for 13 of its "Franklin" oil filters having a total capacity of 1920 gallons. One of these filters (of 240 gallons capacity) was for J. C. Clayton, Johannesburg, South Africa. The Franklin company also received an order for a 2500-gallon oil-purifying system for the East St. Louis & Suburban Railway Company.

F. E. Keyes & Son, 20 Broad street, New York, makers of the Advance feed-water purifier, have received a letter from C. A. Willey, president of C. A. Willey Company, Hunters Point, N. Y., in which he says that he is much pleased with the water purifying and boiler feed system installed for their boilers, the boilers being perfectly clean after one year's run without opening them or using boiler compound.

F. E. Myers & Brothers, Ashland, Ohio, have just completed their annual inventory, closing up one of the most successful years, and doing the largest volume of business ever turned out by them. Their factory has been put in the most favorable condition along the lines of modern methods with regard to equipment and arrangement of all the different departments. The factory is running ten hours a day, with a full force of men.

The Peerless Rubber Manufacturing Company has just completed an important addition to its New Durham, N. J., factory, consisting of a large three-story building which increases its capacity 30 to 35 per cent. It will be devoted to the manufacture of Rainbow and other packings, belting and hose. The demand for Peerless rubber belting has been a stress upon the factory capacity for some months past.

In a recent article written by Earl F. Scott, member A. S. M. E., describing the power plant of the Gulfport & Mississippi Coast Traction Company, he says regarding the gaskets: "All the flanges on the superheated steam header are Van Stone slip-joints. One point regarding this line is of interest: the line is fitted up with Goetze corrugated copper gaskets and during one year's continuous operation there has not been a joint that has required attention.

The Jacobson Engine Company, Chester, Penn., has built and shipped since September, one 130-horse-power automatic twin-tandem gasolene engine for the Salt Lake Hardware Company, Salt Lake City, Utah; one 70-horse-power automatic tandem and one 110-horse-power automatic tandem to the Crown Pipe and Foundry Works, at Jackson, Ohio, for natural gas, and one 300-horse-power automatic twin-tandem engine to operate on producer gas for the Hallidie Machinery Company, Seattle, Wash.

The Ridgway Dynamo and Engine Company, Ridgway, Penn., has sent us a set of templets showing the floor space occupied by its standard generating units in sizes from 10 kilowatts to 200 kilowatts, inclusive. These templets are made to a scale of ¼ inch to the foot and should be of great value to consulting engineers, architects and others, who have occasion to lay out power plants. The company is distributing these templets to all who will have use for them, and will gladly send a set on application.

The Hoppes Manufacturing Company, Springfield, Ohio, reports the sale of a 20,000-horse-power exhaust-steam feed-water heater to the Youngstown Sheet and Tube Company, Youngstown, Ohio. This heater is of the class "T," type "H," pattern, built entirely of cast iron. It is the largest heater ever manufactured by the Hoppes company and possibly the largest ever built by any concern. The heater will be used in connection with one of the Allis-Chalmers steam-turbine units recently purchased by the Youngstown company.

In the development of Japan the progressive Japanese make it a point to purchase nothing but the most up-to-date material. The Japanese were among the very first to anticipate that the turbine engine was to be the foremost power producer of the age and as a consequence a great many American turbine engines have been installed in that far away country. A total of 69 units, aggregating 60,000 horse-power capacity, of the Curtis type of turbo-generator, manufactured by the General Electric Company, of Schenectady, N. Y., have been installed in Japan.

Another step in the development of South America is recorded in cable dispatches from Sao Paulo, Brazil, announcing that the government has accepted the bid of Guinle & Co., of New York City, to furnish electric power in San Paulo. The electric current will at first be used for operating the public water-works system and later for lighting purposes. Steam plants are very expensive in Brazil, owing to the scarcity of coal, and electricity generated by water power at a distance has been the solution of the power question. The action of the Brazilian government in giving this important contract to an American concern is regarded as of the greatest importance in the development of Sao Paulo and other cities in that country.

As an indication of the rapid development in the manufacture of big gas engines, and the importance of the field occupied by this type of prime mover, it is of interest to note that another manufacturer of large Corliss steam engines has actively taken up the manufacture of gas engines. The Wisconsin Engine Company, with works at Corliss, Wis., is building gas engines for all services in sizes from 400 brake-horse-power to 5000 blast-furnace gas in the Otto cycle (4-cycle), ural gas, producer gas, coke-oven gas or blast-furnace gas in the Otto cycle (4-cycle)), and are of the horizontal tandem and twin-tandem double-acting type. This company controls the Sargent patents on internal-combustion engines and has engaged Charles E. Sargent as the engineer of its gas-engine department.

The General offices of the Wheeler Condenser and Engineering Company, will be removed from New York to the works at Carteret, N. J., on January 1, 1908, and all the present New York employees transferred there. The company is erecting a very extensive addition to the present office building in Carteret to accommodate the increased force and to provide room for the executive offices. The drawing room will be enlarged and occupy practically the entire upper floor of the office building, while additional room will also be provided for the engineering department proper. A kitchen from which luncheon will be served at noon will add to the comfort and convenience, and also give that opportunity for the heads of departments to meet daily which has been found of such value and help in similar large establishments.

What is probably a record for the furnishing and installing of steam turbines was made by Allis-Chalmers Company in connection with two 100-kilowatt steam turbines and accessories which that company built for the South Works of the Illinois Steel Company, at South Chicago, Ill. The contract was signed on May 13, 1907; shipment commenced from the factory on May 25, and finished on May 31; the erection of both units was completed July 16, and commercial load was put on the machines July 22. The installation consists of two units, each comprising a 1000-kilowatt Allis-Chalmers steam turbine coupled to a 1000-kilowatt, 25-cycle, 3-phase, 2300-volt, Allis-Chalmers turbo-alternator; together with necessary surface condensing apparatus, pipe connections, and switchboard. The speed of the turbines is 1500 revolutions per minute; each is provided with a direct-connected exciter.

The first session of the annual meeting of the managers of the General Electric Company was held at the main office of the company at Schenectady, N. Y., October 28. The principal part of the afternoon was given over to a discussion of the general situation in the electrical field. Due to the fact that vice-president J. R. Lovejoy had not entirely recovered from a recent illness, vice-president B. E. Sunny, of Chicago, presided. The satisfactory condition of the company's business was indicated by a statement that orders received during the current year to date exceeded those of the corresponding period of last year by fully 15 per cent. The volume of orders and prospective demand for supplies and for the various lines of smaller electrical devices which the company manufactures is very satisfactory. Generally encouraging sentiment regarding the business outlook prevailed among the company's managers. The foreign business continues to show gratifying increases.

The Ball & Wood Company, Elizabethport, N. J., announces the addition to its well known engine business of a line of high-grade air compressors of new and advanced type, designed to meet the modern requirements for air-compressing machinery equal in material and workmanship to the highest class of steam-engine construction. These compressors are the product of their long experience in the design and manufacture of high-grade engines, combined with important new improvements in the air-compressing elements of the machine. They are liberally designed, with large bearings and wearing surfaces, rigid frames, effective lubrication, ample valve areas and intercooling capacities,

securing compressors which operate with minimum noise and friction and at the highest economy. Owing to the increased efficiency and capacity of these machines they are enabled to offer them at a price, based on actual capacity, which compares favorably with compressors of inferior design and cheap construction.

The Penberthy Injector Company was organized in 1886. The inventor of the original Penberthy Injector was William Penberthy, of Leadville, Colo. It is a matter of history unknown to the general public, that the injector so called and invented by Mr. Penberthy was an absolute failure. There were 170 of these injectors made and within sixty days after they were sent out, they were recalled and melted up. In the meantime the company had improved on the original injector, manufacturing 4000, which proved very satisfactory. Experiments developed another still better machine of which some 12,000 were made and sold. At about this time the superintendent of the company, Thomas J. Sweeney, invented the injector that has since then been sold by the Penberthy Injector Company throughout the world, no changes having been made after the first 16,000 were manufactured as above mentioned. In 1886 the company employed four men and now employs from 275 to 300. In May of this year was completed the manufacture of 500,000 Penberthy injectors which does not include 50,000 under the brand of "Auto-Positive" a somewhat different type of injector. In addition to injectors, this company manufactures a large line of boiler- and engine-room appliances, such as lubricators, oil and grease cups, water gages, gage cocks, etc. The present officers of the company are: S. Olin Johnson, president and treasurer, his son Homer S. Johnson, vice-president and secretary.

New Equipment

Boyd Bros., Tullahoma, Tenn., contemplate establishing a 12 or 15 ton ice plant.

The New Kensington (Penn.) Ice and Cold Storage Company will build a $50,000 plant.

The electric light plant owned by the Tillamook (Ore.) Lumber Company was destroyed by fire.

The citizens of St. Paul, Neb., are reported to have voted to establish an electric light plant.

The citizens of Papillon, Neb., are considering the question of establishing an electric light system.

The Waycross (Ga.) Electric Light and Power Company is planning to install additional machinery.

It is reported that the council of Hazelhurst, Ga., is preparing to establish a water system at a cost of about $25,000.

M. B. Foster, of the Foster Lumber Company, Tacoma, Wash., expects to install electrical equipment for house lighting.

The Crescent Engineering Company, Newport, Tenn., will enlarge and improve its plant. A hydro-electric plant of 300 h.p. will be built.

The town of Wood River, Neb., will receive bids about Jan. 15 for the construction of water works and an electric light plant to cost $17,000.

The citizens of Newark, N. J., voted in favor of constructing a municipal electric light plant for lighting the streets. Probable cost $1,000,000.

The Holly Light, Power, Water, Heat and Ice Company has been incorporated at Denver, Col., with a capital stock of $75,000 by R. H. Graham and others.

The Standard Ice and Light Company, Magnolia, Ark., recently incorporated with $50,000 capital stock, will erect a plant. R. L. Moore, president.

It is reported that the Roanoke (Va.) Water Power Company will install a 1000-kilowatt steam turbine auxiliary plant next spring. R. E. Camp manager.

The Standard Light and Ice Company, Magnolia, Ark., has been incorporated with $50,000 capital. R. L. Moore, J. O. Hutchinson and others, incorporators.

The Fayetteville(W. Va.) Water and Light Company has applied for a franchise to construct and operate an electric lighting and power plant, water and gas works.

The Spreckels Sugar Refining Company, Philadelphia, Penn., is to build a three-story addition 109x58 feet to its boiler house, also a brick and steel stack, 170 feet high.

The Huntington (Ind.) National Gas Company has decided to abandon its natural gas wells and will construct and equip an artificial gas plant. J. F. Bippus, president.

The citizens of Merrimac, Mass., are considering the proposition of installing an additional dynamo and engine in the municipal electric light plant. E. D. George is manager.

The Alpha (N. J.) Cement Company is said to be arranging to construct a power plant on the Delaware river next spring. The main offices of the company are in Easton, Penn.

It is said the Kurth Brewing Company, of Columbus, Wis., will erect a new plant at Milwaukee, which will contain two 150 horsepower boilers and one 200 horse-power generator.

The Marquette County Traction Company, of Ishpeming, Mich., is said to have in contemplation the expenditure of $20,000 for new power machinery and improvement of tracks.

It is reported that bids will probably be received in the spring for rebuilding the power plant of the University of Mississippi at University, Miss., which was recently burned.

The citizens of Newport, Tenn., have voted to issue $50,000 bonds to be used for the construction of water works, electric light plant and sewerage system. C. H. Holland, is manager.

The Sioux Falls (S. D.) Light and Power Company is planning to rebuild its plant and water power to the extent of 2500 horse power. Engineers are H. M. Byllesby & Co., Chicago, Ill.

The Elkins (W. Va.) Power Company, recently incorporated, will establish electric light and power plant, it is stated, and install engines, generator and other machinery, at a cost of $30,000.

The Ardmore (I. T.) Traction Company has been incorporated with $500,000 capital stock and will construct and operate plants to generate and produce electricity for illuminating, etc. C. L. Byrne is president.

The City Commissioners are considering the construction of an addition to the municipal power plant which will double the capacity. A gas producer plant will be installed to operate the engines. Address the mayor.

The York-Bangor Slate Company has been formed for the purpose of constructing a plant near Bangor, Penn., to cost $200,000. It is stated that the quarries will be operated by electricity. M. G. Collings, York, Penn., is president.

The Columbia (Miss.) Ice and Power Company will erect an ice plant in connection with electric light plant. Cost of buildings and machinery for both plants is estimated at $40,000 to $50,000. Lee Elder, Biloxi, Miss., is manager.

The Cresson (Penn.) Electric Light Company is planning to install a 60-kilowatt, alternating-current 1100-volt, 133-cycle generator, and also the establishment of a day service. J. F. Marsteller, general manager.

The Belleville (Ill.) and Interurban Railway Company is reported incorporated to construct an electric railway from Belleville to Smithton, $100,000 capital. Jacob Gundlach, Jr., Benj. H. Gundlach, R. W. Hofsommer and others, incorporators.

It is reported that bids will be received about Dec. 20 for constructing an electric railway and power plant for the Midcontinental Traction Company, at Red Fork, I. T. The plant will cost $100,000. Graham Burnham, Tulsa, I. T., is manager.

The Burlington & Bonaparte Interurban Electric Railway Company has filed articles of incorporation for the purpose of constructing an electric railway from Burlington to Bonaparte, Iowa. Capital, $10,000. President, J. A. Johnson, of Bonaparte.

The Mount Vernon & Eastern Railroad has been formed with $1,000,000 capital to construct a steam or electric railroad from Mt. Vernon to Lewisboro, Westchester county. Directors are Oakley Thorne, 135 Broadway, William H. Chesebrough, 111 Broadway, New York, and others.

We understand that the Boston Elevated Railway Company will duplicate its Atlantic avenue station by installing vertical engine-driven units of 6000 kilowatt capacity each. This is an exception in the almost universal application of the steam turbine for large electric-station work.

The Northern Engineering Works, crane and hoist builders, Detroit, Mich., are adding a new power station to their plant. The boiler and coal storage station will be built at once and will be approximately 30x60 feet, one story, fire-proof construction throughout, with reinforced cement roof, iron doors, etc. It will be equipped with Wickes boiler, Murphy stoker and Webster heater. Contracts have been let. The plans were made by Smith, Hinchman & Grylls, engineers and architects, Detroit.

New Catalogs

Jacobson Machine Manufacturing Company Warren, Penn. Bulletin D. Gas and gasolene engines. Illustrated, 20 pages, 6x9 inches.

The Philip Carey Company, Lockland, Sta. R., Cincinnati, Ohio, Catalog. Coverings, Packings, Cement, etc. Illustrated, 70 pages, 6x9 inches.

The Barriett Electric Manufacturing Company, Cincinnati, Ohio. Bulletin No. 106. Polyphase induction motors. Illustrated, 8 pages, 8x10 inches.

Oscar Winter, M. E., Steam Expert and Consulting Engineer, 410 Rockefeller Building, Cleveland, Ohio. Folder. Winter's vacuum trap. Illustrated.

Central Station Steam Company, Detroit, Mich. Catalog. Equipment and supplies for central station steam distribution. Illustrated, 18 pages, 6x9 inches.

H. B. Underwood & Company, 1025 Hamilton street, Philadelphia, Penn. Catalog. Portable tools for railway repair shops. Illustrated, 64 pages, 6x9 inches.

Golden-Anderson Valve Specialty Company, Fulton building, Pittsburg, Pa. Cata-

log No. 9. Automatic valves and traps. Illustrated, 56 pages, 5½x8 inches.

James Beggs & Company, 109 Liberty street, New York. Catalog. Blackburn-Smith feed water filter and grease extractor. Illustrated, 16 pages, 6x9 inches.

The Sargent Steam Meter Company, 1325 First National Bank building, Chicago, Ill. Catalog. Sargent automatic gas calorimeter. Illustrated, 12 pages, 3½x6 inches.

Hydraulic Oil Storage Company, Detroit, Mich. Pamphlet. Saved a Detroit man 23½ per cent. of his yearly fuel and oil bill and how it was done. Illustrated.

The New Process Raw Hide Company, Syracuse, N. Y. Catalog. New Process noiseless pinions, accurately cut metal gears. Illustrated, 86 pages, 3½x6 inches.

The Marion Incline Filter and Heater Company, Marion, Ohio. Catalog G-1. Marion system of feed-water heating and purification. Illustrated, 29 pages, 6x9 inches.

Harrison Safety Boiler Works, Seventeenth street and Allegheny avenue, Philadelphia, Penn. Pamphlet. Cochrane feed-water heaters. Illustrated, 8 pages, 6x9 inches.

Austin Separator Company, Detroit, Mich., J. H. Pearson, Sales Agent, 122-130 Centre street, New York. Catalog. Steam and oil separators. Illustrated, 52 pages, 6x9 inches.

The Hayden & Derby Manufacturing Company, 85 Liberty street, New York. Catalog. Metropolitan injectors. H-D ejectors and jet appliances. Illustrated, 52 pages, 6x9 inches.

Buffalo Forge Company, Buffalo, N. Y. Catalog No. 177. Forges, blacksmith tools, blowers, exhausters, heating and ventilating pumps, etc. Illustrated, 246 pages, 3½x6½ inches.

The Tudor Boiler Manufacturing Company, Cincinnati, Ohio. Catalog No. 12. Tubular and water tube boilers, pressure tanks, feed water heaters. Illustrated, 96 pages, 6x9 inches.

Robb Engineering Company, Ltd., Amherst, N. S. Catalog. Steam Boilers. Illustrated, 49 pages, 6x9 inches. Catalog. Robb-Armstrong engines. Illustrated, 67 pages, 6x9 inches.

Goldschmidt Thermit Company, 90 West street, New York. Pamphlet. Fire brick molds for welding locomotive frames by the Thermit process. Illustrated, 12 pages, 6x9 inches.

Hoppes Manufacturing Company, Springfield, Ohio. Catalog. Feed-water heaters, purifiers, steam separators, oil eliminators, exhaust heads. Illustrated, 40 pages, 6x9 inches.

Lagonda Manufacturing Company, Springfield, Ohio. Catalog F. Weinland boiler tube cleaner, direct motor cleaner, reseating machine, etc. Illustrated, 48 pages, 6x9 inches.

The Osborn Manufacturing Company, Cleveland, Ohio. Catalog No. 122. Foundry supplies, brushes and brooms, hardware specialties. Illustrated, 199 pages, 6x9 inches.

Dossert & Company, 242-244 West Forty-first street, New York. Catalog. Solderless electrical connectors or cable joints for stranded or solid wire. Illustrated, 24 pages, 4½x7 inches.

Lidgerwood Manufacturing Company, 96 Liberty street, New York. Pamphlet. The Lidgerwood-Miller marine cableway for coaling in a seaway. Illustrated, 48 pages, 8½x11 inches.

Engineering Specialty Company, 143 Liberty street, New York. Bulletin No. 106. Direct current motors, dynamos, motor generators, dynamotors. Illustrated, 16 pages, 4½x8½ inches.

Berry Engineering Company, Chester, Penn. Catalog. Feed water regulators, damper regulators, steam pump governors, safety boilers, feed water heaters and purifiers. Illustrated, 5½x8 inches.

Northern Specialty Company, 63-65 Columbia street, Utica, N. Y. Catalog and circular. "Approved" combination water gage and automatic safety valves and automatic safety check valves. Illustrated.

The D. T. Williams Valve Company, Cincinnati, Ohio. Pamphlet. Williams Regrinding Valves. A treatise on construction, method of operation and renewal of seat bearings. Illustrated, 15 pages, 3½x6 inches.

Fort Wayne Electric Works, Fort Wayne, Ind. Bulletin No. 1098. Type MPL belted generators for light and power. Illustrated, 6 pages, 8x10½ inches. Bulletin No. 1100. Small direct current motors, type L. Illustrated, 6 pages, 8x10½ inches.

Goldschmidt Thermit Company, 90 West street, New York. Pamphlet. Applications of Thermit in foundry practice. Illustrated, 12 pages, 6x9 inches. Pamphlet. Butt-welding wrought iron and steel pipes and rods. Illustrated, 12 pages, 6x9 inches.

General Electric Company Schenectady, N. Y. Bulletin No. 4502. Knife blade lever switches. Type L, form D-12. Illustrated, 20 pages, 8x10½ inches. Bulletin No. 4498. Thomson single phase high torque induction wattmeters. Illustrated, 12 pages, 8x10½ inches.

General Electric Company, Schenectady, N. Y. Bulletin No. 4517. Isolated plant switchboard panels with fuses. Illustrated. Bulletin No. 4516. MR circuit breakers. Illustrated. Bulletin No. 4518. Electric hoists. Illustrated. Bulletin No. 4520. Engine type continuous current generators, Form R. Illustrated.

Sight Feed Oil Pump Company, Milwaukee, Wis. Bulletin 203. Richardson automatic sight feed oil pump. Illustrated, 23 pages, 3½x6½ inches. Bulletin No. 107. Richardson combination tank and gang oilers, type A. Illustrated, 5 pages, 3½x6½ inches. Bulletin No. 105. Richardson sight feed oil pump, bracket model. Illustrated, 8 pages, 3½x6½ inches.

Help Wanted

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

ENGINEERS paid for selling Tupper grates. H. McElroy, 315 Willings Ave., Philadelphia.

ENGINEER for 100 h.p. producer gas plant; must have experience; twenty miles from New York. "Producer," care POWER.

WANTED—Territorial agents, on contract at liberal commission, to demonstrate in boiler plants a patented machine of recognized worth, selling at moderate price. For further particulars apply, with reference, to Thomas Andrews Mfg. Co., Rockaway, N. J.

WANTED—Master mechanic for Michigan iron mine; applicant must have had experience with mine machinery and especially with boilers, air compressors and large pumps; man with machine shop experience preferred; to a man who can prove himself economical in the use of men and steam a good position is offered; communications will be considered confidential if so desired. Address, giving experience in detail, references and pay expected to "C. Z. R.," POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—POSITION as engineer or electrician; ten years' experience; age 28 years; can furnish best of reference. Address "R. F. D.," POWER.

SITUATION WANTED by a first-class stationary engineer; at present chief engineer of a large power plant; I. C. S. graduate; will go anywhere. Box 298, POWER.

EXPERIENCED electrician desires position in manufacturing plant; familiar with motors, generators and wiring; D.C. and single phase alternating current. Address Box 299, POWER.

ELECTRICAL and steam engineer desires position with erecting engineers, machinery merchants, power plant, mining or construction company; practical experience; good references. Box 296, POWER.

DRAFTSMAN; technical graduate; 5 years' experience on power plant work erecting and designing both steam and electrical end; familiar with steam turbine design and operation; good references. Box 297, POWER.

WANTED—Position as mechanical engineer or assistant; technical graduate; 12 years' experience in supervising erecting work; practical experience in cement manufacture lime, producer gas work, latter preferred. Box 301, POWER.

POSITION WANTED as chief engineer or master mechanic by an A-1 man with both technical and practical training; can furnish best of references; have a first-class mechanic's outfit; will go anywhere; am 37 years old and married. Box 300, POWER.

WANTED—Position as general master mechanic, chief engineer in railroad, power and lighting, copper smelting plants, paper mills; carrying unlimited license State of Massachusetts, New York City and New Jersey; go any part of the United States. Box 302, POWER.

POSITION WANTED as chief engineer or superintendent of power plant; familiar with power, lighting and railway systems; thoroughly experienced with water power; reciprocating and turbine engines, also with various types of water tube boilers; am a capable man with best of reference. Box 287, POWER.

POSITION WANTED — Young man, 7 years' experience on pumps, elevators, high speed and Corliss engines and turbines and condensers, a.c. and d.c. generators and motors; own tools; good practical, industrious and sober man who is at home in any part of plant; best of references. Address Box 303, POWER.

AN ENGINEER having had experience with multitubular and water tube boilers, various classes of pumps and condensers, blowing and power engines, steam turbines, direct and alternating-current generators; have been chief of ice plants and at present chief engineer of a power house containing turbines and Corliss engines; 34 years old, married and strictly temperate; wants to make a change. Box 295, POWER.

WANTED—Position as sales manager or purchasing agent, with chance to gradually secure interest in the business; 10 years' experience in the manufacture and sale of steam and gasoline engines, steam and power pumps, electrical machinery, etc., including shop and drafting room experience; was salesman for several well known concerns, and later sales manager for large machinery and supply house; young man; technology graduate; desire to locate where knowledge of engineering and commercial practice, Yankee sense, and business diplomacy can be used to best advantage. Address Box 292, POWER.

Miscellaneous

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

ENGINES AND BOILERS, ⅛ to 2 h.p. engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

IF YOU DESIRE to learn the latest improvement in steam boilers, correspond with the Detroit Water Tube Boiler Co. See their advertisement on page 264.

WANTED—Engineers, send us the name and address of ten engineers and receive a valuable present by return mail. Advance Engineering Co., Mason City, Ia.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make free examination and report if patent can be had, and exact cost.

WE FURNISH engines for low pressure and high pressure, slow speed and high speed, adapted for all purposes. Send for circular and prices. Greenfield Steam Engine Wks., Harrison, N. J.

ENGINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

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We desire to make an arrangement for the manufacture of a Gas Producer of the suction and pressure types, we desire a type of producer that has been in successful operation. We will not consider an outright purchase but would like to manufacture on a royalty basis for territory or exclusive rights. Address, "Gas Producer," this office and replies will be forwarded to us.

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A Treatise on the History, Manufacture, Composition, Uses, and Possibilities of Industrial Alcohol in the various Countries permitting its Use, and the Laws and Regulations Governing the Same, including the United States, with concise Tables, Methods, and Notes for the Use of the Engineer, Chemist, Manufacturers of Alcohol and Alcohol Making and Using Apparatus, including Alcohol Motors, Engines, Illuminating Lamps, and Heating and Cooking Stoves. By RUFUS FROST HERRICK.

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For Sale

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

FOR SALE—25 H. P. double cylinder gasolene engine vertical, very steady governor, suitable for electric lighting; cheap. Termaat & Monahan Co., Oshkosh, Wis.

FOR SALE—Cyclopedia of electricity; five volumes, three-quarters red morocco, leather binding; books are in fine condition; used but short time; cost $19; will sell for $9. Address "R. S. M.," Box 425, Chicago, Ill.

FOR SALE—A slightly used engineering library. Steam, electrical, mechanical. Twelve volumes bound in three quarters red morocco leather. Cost new, $60. Will sell for $18. Address "R. L. N.," Box 425, Chicago, Ill.

FOR SALE—Cyclopedia of engineering; steam, electrical, mechanical; bound in three quarters morocco; five volumes; cost new, $19; are in fine condition; will sell for $9. Address "M. B. T.," Box 425, Chicago, Ill.

LOCOMOTIVE 17x24, first class order, equipped with air brake; monitor injector and two sixty-foot passenger coaches used at Luna Park in Great Train Robbery. Dr. M. J. Potter, 138 East 25th St., New York.

FOR SALE—1—15 horse power and 1—32 horse power. Fairbanks gasolene engine; neither have been used more than a week or ten days, and both are absolutely as good as new. Address The Jeffrey Manufacturing Company, Columbus, Ohio.

FOR SALE—Newcomb engine; patent riding cutoff, throttling governor, in first class condition in every particular; diameter of piston, 15"; stroke, 36"; now doing 72 revolutions per minute, developing 90 h.p., under pressure of 80 lb. Thayer Foss Company, Peabody, Mass.

FOR SALE—500 kw. d.c. railway generator, belt driven, three bearing, e.m.f. 550 six pole, 320 r.p.m., serial number 149054, manufactured by the Westinghouse Electric and Manufacturing Company; machine in good condition. For further information, address Detroit United Railway, Detroit, Mich.

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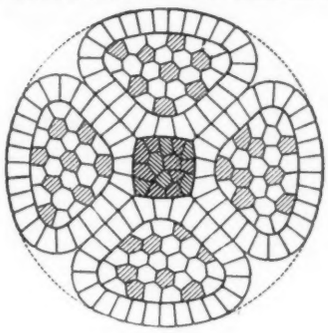

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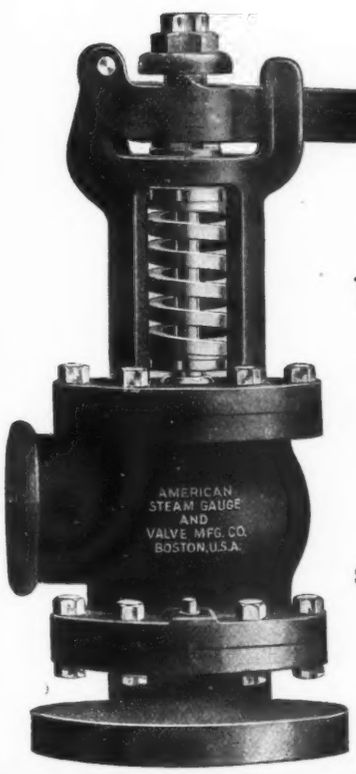

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Packings, Pump Valve
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Packings, Rod
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Boston Belting Co., Boston, Mass.
Bowers Rubber Co., San Francisco, Cal.
Brandt, Randolph, New York.
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Chesterton & Co., A. W., Boston, Mass.
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Greene, Tweed & Co., New York.
Johnson Co., Henry, Jersey City, N. J.
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Revere Rubber Co., Boston, Mass.
Robertson & Sons, Jas. L., New York.
Sayen, Osgood, Philadelphia, Pa.
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Swain Lubricator Co., Chicago, Ill.
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Packings, Valve Stem
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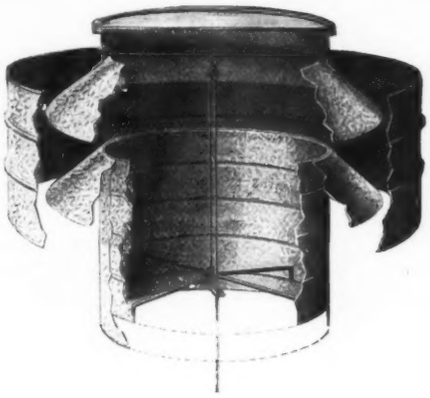

Notice Sliding Sleeve Damper

(PATENTED)

A Burt Ventilator is one of the most profitable investments any owner of a factory can make. Where a room is filled with impure odors or gases—good work is out of the question. Why not provide for an abundance of fresh air by adopting the "Burt?" Made with a metal top instead of glass top when desired. Except the top, both are exactly alike in construction—but the metal top style is a ventilator only—does not admit light. Ask about them.

Your address brings our new 80-page catalog.

The Burt Manufacturing Co.,
232 Main St., Akron, Ohio, U.S.A.

The Cross Oil Filter

makes the thorough cleansing of used lubricating oil a reality. Dirt and grit are removed from oil by straining through waste, then washing in pure warm water.
Costs but a little a year to maintain—returns substantial profits.

Write for list of users.

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The Burt Manufacturing Co.,
232 Main St., Akron, Ohio, U.S.A.

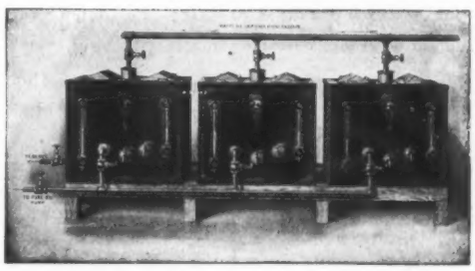
Burt Exhaust Heads

are equipped with malleable iron bases and drips (galvanized)—thus making them much stronger and more durable than other kinds. Seams and attachments are water tight—the head cannot overload or blow up. They will not break or rust, because painted with anti-rust paint—last a lifetime.
The U. S. Steel Corp. have 102 Burt Exhaust Heads in daily use.

Your address brings our new 80-page catalog.

The Burt Manufacturing Co.,
Largest manufacturers of oil filters in the world
232 Main St., Akron, Ohio, U.S.A.
Also supplied by Engine Builders, Dealers and Power Contractors.

Burt Unit Oil Filter



Any Number Of Units

can be used, each one having a capacity of from 200 to 250 gallons per 24 hours. Unit Oil Filters will enable you to SAVE your drip oil. They filter it, wash it, clean and purify it, returning it in a pure condition to be used over again. And this process can be repeated over and over. Thus you can positively save from 50% to 90% on your oil bills and get your money back in short order. Write for our new 80-page catalog.

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The Burt Manufacturing Co.,
Largest manufacturers of oil filters in the world
232 Main St., Akron, Ohio, U.S.A.
Also supplied by Engine Builders, Dealers and Power Contractors.

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Jacobson Engine Co., Chester, Pa.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Power & Mining Mach. Co., Cudahy, Wis.

Publishers

Henley Pub. Co., Norman W., New York.
Hill Publishing Co., New York.
Van Nostrand Co., D., New York.

Pulley Covers

Warren Co., Chicago, Ill.

Pulleys

American Pulley Co., Phila., Pa.
Dodge Mfg. Co., Mishawaka, Ind.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Oneida Steel Pulley Co., Oneida, N. Y.
Philips Pressed Steel Pulley Works, Philadelphia, Pa.

Pumps, Air

Dean Bros. Steam Pump Works, Indianapolis, Ind.
Deane Steam Pump Co., Holyoke, Mass.
Du Bois Iron Works, Du Bois, Pa.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Centrifugal

Alberger Condenser Co., New York.
Deane Steam Pump Co., Holyoke, Mass.
Morris Machine Works, Baldwinsville, N. Y.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Electric

Dean Bros. Steam Pump Works, Indianapolis, Ind.
Du Bois Iron Works, Du Bois, Pa.
Northern Electrical Mfg. Co., Madison, Wis.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Pumps, Hydraulic

Allis-Chalmers Co., Milwaukee, Wis.
Advance Packing & Supply Co., Chicago, Ill.

Pumps, Oil

Burt Mfg. Co., Akron, O.
Detroit Lubricator Co., Detroit, Mich.
Du Bois Iron Works, Du Bois, Pa.
Huyette Co., Paul B., Philadelphia, Pa.
Lunkenheimer Co., Cincinnati, O.
Manzel Bros. Co., Buffalo, N. Y.
Sherwood Mfg. Co., Buffalo, N. Y.
Sight Feed Oil Pump Co., Milwaukee, Wis.

Pumps, Power

Advance Packing & Supply Co., Chicago, Ill.
Blackmer Rotary Pump, Power & Mfg. Co., Petoskey, Mich.
Deane Steam Pump Co., Holyoke, Mass.
Myers & Bros., F. E., Ashland, O.
Patterson & Co., Frank L., New York.
Stewart Heater Co., Buffalo, N. Y.
Whitlock Coil Pipe Co., Hartford, Conn.

Pumps, Rotary

Blackmer Rotary Pump, Power & Mfg. Co., Petoskey, Mich.

Pumps, Steam

Advance Packing & Supply Co., Chicago, Ill.
Buffalo Steam Pump Co., Buffalo, N. Y.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Deane Steam Pump Co., Holyoke, Mass.
Du Bois Iron Works, Du Bois, Pa.
Fairbanks, Morse & Co., Chicago, Ill.
Gardner Governor and Separator Co., Quincy, Ill.
Kelley & Son, Benj. F., New York.
Mason Regulator Co., Boston, Mass.
Minneapolis Steel & Machry. Co., Minneapolis, Minn.
Murray Iron Works Co., Burlington, Iowa.

Pumps, Steam—*Continued.*

Prescott Steam Pump Co., Fred M., Milwaukee, Wis.
Safety Equipment Mfg. Co., Chicago, Ill.
Warren Steam Pump Co., Warren, Mass.
Wheeler Condenser & Eng. Co., New York.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.
Wilson & Roake, New York.

Pumps, Triplex

Minneapolis Steel & Mchry. Co., Minneapolis, Minn.

Pumps, Turbine

Alberger Condenser Co., New York.

Pumps, Vacuum

Alberger Condenser Co., New York.
Deane Steam Pump Co., Holyoke, Mass.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

Rams, Steam

Penberthy Injector Co., Detroit, Mich.

Reamers

Curtis & Curtis Co., Bridgeport, Conn.

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American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.
Thompson & Co., Richard, New York.
Trill Indicator Co., Corry, Pa.

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De La Vergne Machine Co., New York.
Empire State Engineering Co., New York.
Vilter Mfg. Co., Milwaukee, Wis.
Vogt Machine Co., Henry, Louisville, Ky.
York Mfg. Co., York, Pa.

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Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Mason Regulator Co., Boston, Mass.
Robertson & Sons, Jas. L., New York.
Strong, Carlisle & Hammond Co., Cleveland, O.
Thompson & Co., Richard, New York.

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Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Jerguson Mfg. Co., Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Mason Regulator Co., Boston, Mass.
Safety Equipment Mfg. Co., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Philadelphia, Pa.
Williams Gauge Co., Pittsburg, Pa.

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American Boiler Economy Co., Philadelphia, Pa.
American District Steam Co., Lockport, N. Y.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este & Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Lagonda Mfg. Co., Springfield, O.
Mason Regulator Co., Boston, Mass.
Strong, Carlisle & Hammond Co., Cleveland, O.
Thompson & Co., Richard, New York.

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Underwood & Co., H. B., Philadelphia, Pa.

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Lagonda Mfg. Co., Springfield, O.
Leavitt Machine Co., Orange, Mass.
Liberty Mfg. Co., Pittsburg, Pa.

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American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashcroft Mfg. Co., New York.
Ashton Valve Co., Boston, Mass.

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Cling Surface Mfg. Co., Buffalo, N. Y.

Rope Transmission

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Dodge Mfg. Co., Mishawaka, Ind.
Plymouth Cordage Co., No. Plymouth, Mass.

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National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Rubber Co., Jeanette, Pa.
Quaker City Rubber Co., Philadelphia, Pa.
Rhoades & Sons, J. E., Philadelphia, Pa.

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American School of Correspondence, Chicago, Ill.
International Correspond. Schools, Scranton, Pa.

Second Hand Machinery

Hewes & Phillips Iron Works, Newark, N. J.
Jones & Co., Chas. H., Chicago, Ill.
Wickes Bros., Saginaw, Mich.
Williams, E. O., Chicago, Ill.
Wilson & Roake, New York.

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Baragwanath & Son, Wm., Chicago, Ill.
Crane Co., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Goubert Mfg. Co., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hershey Foundry & Machine Co., Manheim, Pa.
Hoppes Mfg. Co., Springfield, O.
Hussey, McCann & Co., New York.
Loew Mfg. Co., Cleveland, O.
Marion Incline Filter and Heater Co., Marion, Ohio.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Ohio Blower Co., Cleveland, O.
Potter Separator Co., Newburgh, N. Y.
Robertson & Sons, Jas. L., New York.
Thompson & Co., Richard, New York.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser and Engineering Co., New York.
Wright Mfg. Co., Detroit, Mich.

Separators, Oil & Water

Keyes & Son, F. E., New York.

Separators, Steam

Austin Separator Co., Detroit, Mich.
Baragwanath & Son, Wm., Chicago, Ill.
Crane Co., Chicago, Ill.
d'Este & Co., Julian, Boston, Mass.

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Direct Separator Co., Syracuse, N. Y.
Gardner Governor and Separator Co., Quincy, Ill.
Goubert Mfg. Co., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hershey Foundry & Machine Co., Manheim, Pa.
Hoppes Mfg. Co., Springfield, O.
Loew Mfg. Co., Cleveland, O.
Marion Incline Filter and Heater Co., Marion, Ohio.
Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Ohio Blower Co., Cleveland, O.
Patterson & Co., Frank L., New York.
Potter Separator Co., Newburgh, N. Y.
Power Plant Specialty Co., Chicago, Ill.
Robertson & Sons, Jas. L., New York.
Simonds Heating & Specialty Co., Detroit, Mich.
Sims Co., Erie, Pa.
Thompson & Co., Richard, New York.
Webster & Co., Warren, Camden, N. J.
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Minneapolis Steel & Mchy. Co., Minneapolis, Minn.

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Morrin Climax Boiler Co., Brooklyn, N. Y.

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Beggs & Co., James, New York.
Boston Belting Co., Boston, Mass.
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Wright Mfg. Co., Detroit, Mich.

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Liberty Mfg. Co., Pittsburg, Pa.
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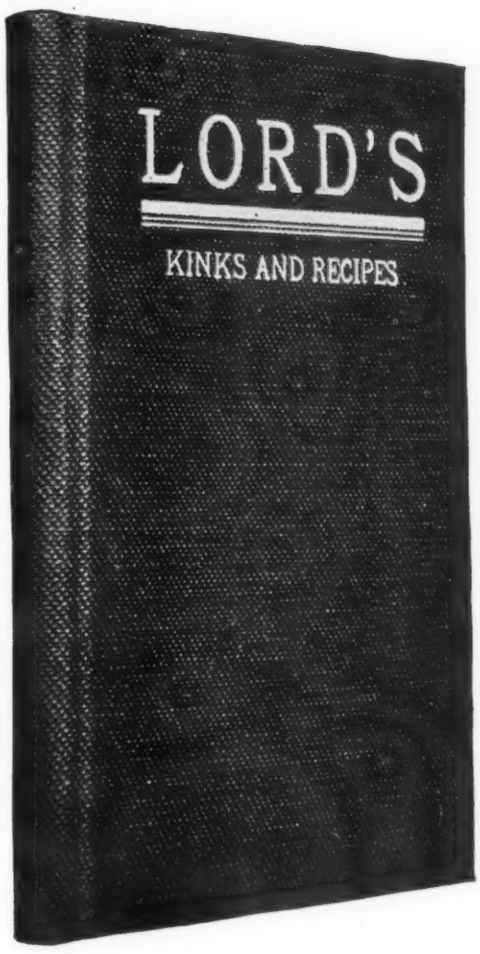
LORD'S

Send us a sample of scale from your boiler and write to us answering these questions.

We will analyze the scale, send an engraved Certificate of Analysis and also the book, Kinks and Recipes, all free of charge.

We will also send you considerable information about our chemicals, which as you know, are compounded according to the most advanced Laboratory methods.



QUESTIONS

Your name and address.
Name and address of firm owning boilers.
How many boilers.
Horse-power of each.
How often opened for cleaning.
Hours run each day.
Compound used now.

Address replies to Laboratory No. 6.

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New Bedford Boiler & Mach. Co., New Bedford, Mass.

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Revere Rubber Co., Boston, Mass.

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Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

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Mesta Machine Co., Pittsburg, Pa.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Oneida Steel Pulley Co., Oneida, N. Y.
Philips Pressed Steel Pulley Co., Philadelphia, Pa.
Plymouth Cordage Co., No. Plymouth, Mass.
Rhoads & Sons, J. E., Philadelphia, Pa.
Warren Co., Chicago, Ill.

Traps
American District Steam Co., Lockport, N. Y.
Anderson Co., V. D., Cleveland, O.
Bonar & Co., Jas., Pittsburg, Pa.
Crane Co., Chicago, Ill.
Davis Co., John, Chicago, Ill.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Dunham Co., C. A., Marshalltown, Iowa.
Flinn, Richard J., W. Roxbury Station, Boston, Mass.
Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Harrison Safety Boiler Works, Philadelphia, Pa.
Houghton & Co., E. F., Philadelphia, Pa.
Huyette Co., Paul B., Philadelphia, Pa.
Marion Incline Filter and Heater Co., Marion, Ohio.
Nason Mfg. Co., New York.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Ohio Blower Co., Cleveland, O.
Platt & Co., John, New York.
Reliance Gauge Column Co., Cleveland, O.
Ryan, E. J., Danville, Ill.
Safety Equipment Mfg. Co., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.
Templeton Mfg. Co., Boston, Mass.
Thompson & Co., Richard, New York.
Watson & McDaniel Co., Philadelphia, Pa.

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Williams Gauge Co., Pittsburg, Pa.
Wilson & Roake, New York.
Wright Mfg. Co., Detroit, Mich.

Tube Cleaners
See Cleaners (Boiler Tube)

Tube Cutters
Lagonda Mfg. Co., Detroit, Mich.

Tubing
Flower Steam Specialty Co., Walter L., St. Louis, Mo.
Western Tube Co., Kewanee, Ill.

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Dake American Steam Turbine Co., Grand Rapids, Mich.
De Laval Steam Turbine Co., Trenton, N. J.
General Elec. Co., Schenectady, N. Y.
Hooven, Owens, Rentschler Co., Hamilton, O.
Kerr Turbine Co., Wellsville, N.Y.
Westinghouse Machine Co., Pittsburg, Pa.
Wing Mfg. Co., L. J., New York.

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Crane Co., Chicago, Ill.
Dart Mfg. Co., E. M., Providence, R. I.
Jefferson Union Co., Lexington, Mass.
Western Tube Co., Kewanee, Ill.
Williams, Franklin, New York.

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Rhoads & Sons, J. E., Phila., Pa.
Schieren & Co., Chas. A., New York.

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Mechanical Rubber Co., Cleveland, O.

Valve Reseating Machine
Leavitt Machine Co., Orange, Mass.

Valve Seat Planing Machine
Underwood & Co., H. B., Philadelphia, Pa.

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Walch & Wyeth, Chicago, Ill.

Valves, Automatic
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Golden-Anderson Valve Specialty Co., Pittsburg, Pa.
Lagonda Mfg. Co., Springfield, O.
Northern Specialty Co., Utica, N. Y.
Safety Equipment Mfg. Co., Chicago, Ill.
Webster & Co., Warren, Camden, N. J.

Valves, Back Pressure
Crane Co., Chicago, Ill.
Schutte & Koerting Co., Philadelphia, Pa.
Walch & Wyeth, Chicago, Ill.

Valves, Balance
Mason Regulator Co., Boston, Mass.

Valves, Boiler Stop
Crane Co., Chicago, Ill.
Davis Regulator Co., G. M., Chicago, Ill.

Valves, Blow-off
Ashton Valve Co., Boston, Mass.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Crane Co., Chicago, Ill.
Hancock Inspirator Co., New York.
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Liberty Mfg. Co., Pittsburg, Pa.
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Lunkenheimer Co., Cincinnati, O.
Pittsburg Gage & Supply Co., Pittsburg, Pa.
Sayen, Osgood, Philadelphia, Pa.
Western Tube Co., Kewanee, Ill.

Valves, By-Pass
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Mason Regulator Co., Boston, Mass.

Valves, Check
Crane Co., Chicago, Ill.
Greene, Tweed & Co., New York.
Hayden & Derby Mfg. Co., New York.
Kennedy Valve Mfg. Co., New York.
Ludlow Valve Mfg. Co., Troy, N. Y.
Northern Specialty Co., Utica, N. Y.
Pittsburgh Valve and Fittings Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.
Western Tube Co., Kewanee, Ill.

Valves, Cut-out
Walch & Wyeth, Chicago, Ill.

Valves, Cylinder Relief
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Consolidated Safety Valve Co., New York.
Lunkenheimer Co., Cincinnati, O.

Valves, Electrically Operated Trip
Schutte & Koerting Co., Philadelphia, Pa.

Valves, Exhaust Relief
Alberger Condenser Co., New York.
Davis Co., John, Chicago, Ill.
Deane Steam Pump Co., Holyoke, Mass.
Walch & Wyeth, Chicago, Ill.

Valves, Foot
Newman Mfg. Co., New York.
Walch & Wyeth, Chicago, Ill.

Valves, Free Exhaust
Schutte & Koerting Co., Philadelphia, Pa.

Valves, Gate
Advance Packing & Supply Co., Chicago, Ill.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Greene, Tweed & Co., New York.
Kennedy Valve Mfg. Co., New York.
Ludlow Valve Mfg. Co., Troy, N. Y.
Nelson Valve Co., Wyndmoor, Montgomery Co., Pa.
Pittsburgh Valve & Fittings Co., Pittsburg, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.
Western Tube Co., Kewanee, Ill.

Valves, Globe
Advance Packing & Supply Co., Chicago, Ill.
Crane Co., Chicago, Ill.
Detroit Lubricator Co., Detroit, Mich.
Eastwood Wire Mfg. Co., Belleville, N. J.
Hancock Inspirator Co., New York.
Ludlow Valve Mfg. Co., Troy, N. Y.
Lunkenheimer Co., Cincinnati, O.
Nelson Valve Co., Wyndmoor, Montgomery Co., Pa.
Pittsburgh Valve & Fittings Co., Pittsburg, Pa.
Pittsburgh Valve, Fdry. and Construction Co., Pittsburg, Pa.
Powell Co., Wm., Cincinnati, O.
Western Tube Co., Kewanee, Ill.

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Schutte & Koerting Co., Philadelphia, Pa.

Valves, Lever & Throttle
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Mason Regulator Co., Boston, Mass.
Powell Co., Wm., Cincinnati, O.

Valves, Non-return
Walch & Wyeth, Chicago, Ill.

Valves, Pop Safety
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Ashton Valve Co., Boston, Mass.
Consolidated Safety Valve Co., New York.
Kunkle & Co., E. B., Fort Wayne, Ind.
Lunkenheimer Co., Cincinnati, O.
Star Brass Mfg. Co., Boston, Mass.

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Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Revere Rubber Co., Boston, Mass.

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See Pressure Regulators.

Valves, Safety
Advance Packing & Supply Co., Chicago, Ill.
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Consolidated Safety Valve Co., New York.
Kunkle & Co., E. B., Fort Wayne, Ind.
Pittsburg Valve, Fdry. & Construction Co., Pittsburg, Pa.
Walch & Wyeth, Chicago, Ill.
Western Tube Co., Kewanee, Ill.

Valves, Stop Check
Northern Specialty Co., Utica, N. Y.
Schutte & Koerting Co., Philadelphia, Pa.

Valves, Water Relief
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
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Consolidated Safety Valve Co., New York.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.

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Burt Mfg. Co., Akron, O.
Wing Mfg. Co., L. J., New York.

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Curtis & Curtis, Bridgeport, Conn.
Greene, Tweed & Co., New York.

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Kelly Foundry & Machine Co., Goshen, Ind.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Reliable Water Gauge Co., St. Louis, Mo.
Reliance Gauge Column Co., Cleveland, O.
Robertson & Sons, Jas. L., New York.
Safety Equipment Mfg. Co., Chicago, Ill.
Williams Gauge Co., Pittsburg, Pa.
Wright Mfg. Co., Detroit, Mich.

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Keyes & Son, F. E., New York.

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Dodge Mfg. Co., Mishawaka, Ind.
Harrison Safety Boiler Works, Philadelphia, Pa.
Marion Incline Filter & Heater Co., Marion, O.
Scaife & Sons Co., Wm. B., Pittsburg, Pa.

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Greene, Tweed & Co., New York.
Lunkenheimer Co., Cincinnati, O.
Schaeffer & Budenberg Mfg. Co., Foxboro, Mass.

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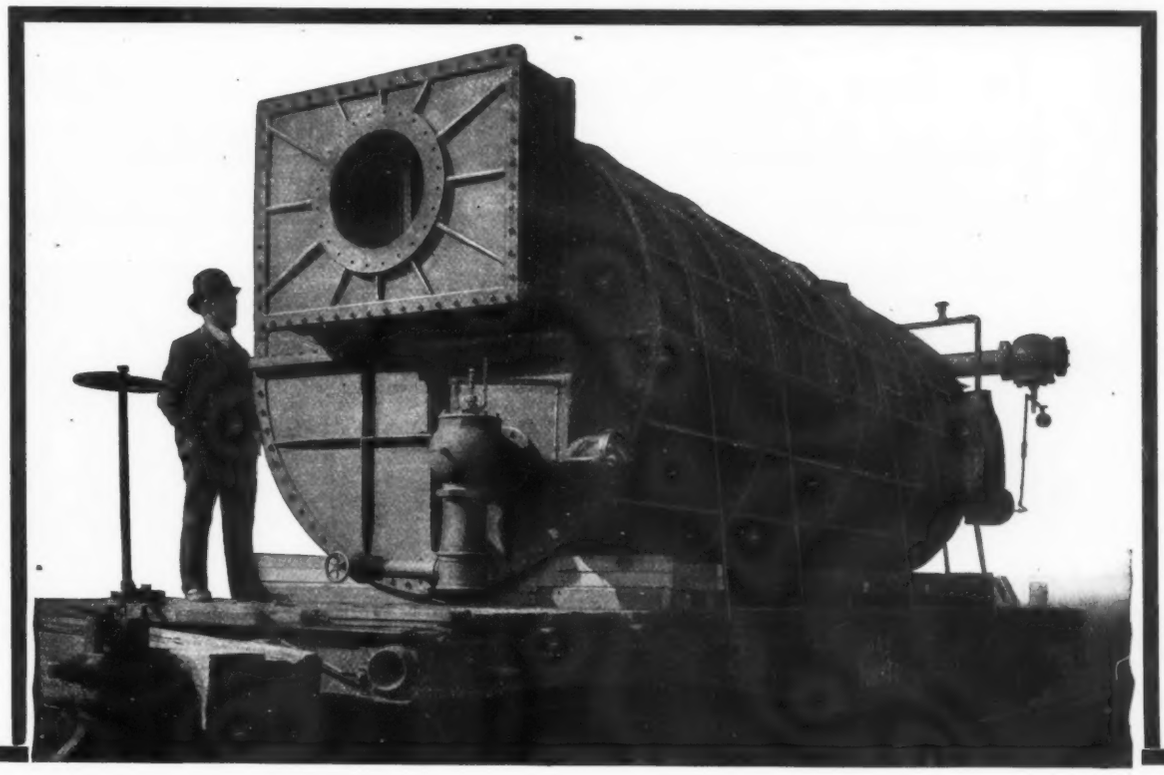
Ohio Brass Co., Mansfield, O.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Wrenches, Pipe
Ohio Brass Co., Mansfield, Ohio.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.



A 10,000 H. P.

COCHRANE FEED-WATER-HEATER

Recently shipped to a large steam turbine power plant. Cochrane Heaters are preferred for power station work for several reasons:

First, as they are not put under boiler pressure they are adapted to large units.

Second, they save very considerable quantities of water and heat which a closed heater wastes in the form of drips.

Third, they drive off from the feed-water the air and gases which a closed heater would pass along to the boiler and ultimately to the condenser, where they would reduce the vacuum by about an inch. This lower vacuum in the case of a turbine, would mean an increase of 5% in steam consumption.

Fourth, the Cochrane Heater serves as a hot well for all condensation or drips about the plant suitable for boiler feed. It thus replaces a lot of other apparatus while performing all functions more perfectly.

Fifth, the Cochrane Heater precipitates a large part of the scale-forming matter, thereby protecting the boilers and reducing boiler-cleaning and repair bills. As you know, a closed heater leaves all this stuff for the boiler to deal with.

Sixth, a Cochrane Heater maintains its full efficiency no matter how long it may be used, or how much scale-forming matter may collect within it. A closed heater rapidly loses its efficiency from the accumulation of oil from the exhaust steam upon one side of the heater and of scale-forming matter on the other.

Seventh, Cochrane Heaters are always equal to the peak load.

A Cochrane Heater enables the auxiliaries about a plant to be operated with a thermodynamic efficiency of nearly 100%. If you would like further information, send for our Special Booklet "15H" on Heating Boiler Feed-Water in Condensing Plants.

HARRISON SAFETY BOILER WORKS,

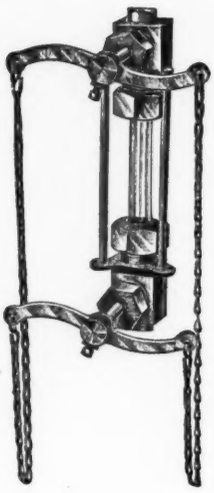
17th AND CLEARFIELD STREETS, PHILADELPHIA, PA.

It Is One Thing To Be Brave And Quite Another To Be Foolhardy.

THE OLD WAY.

Fool hardy—"Bold without judgment."

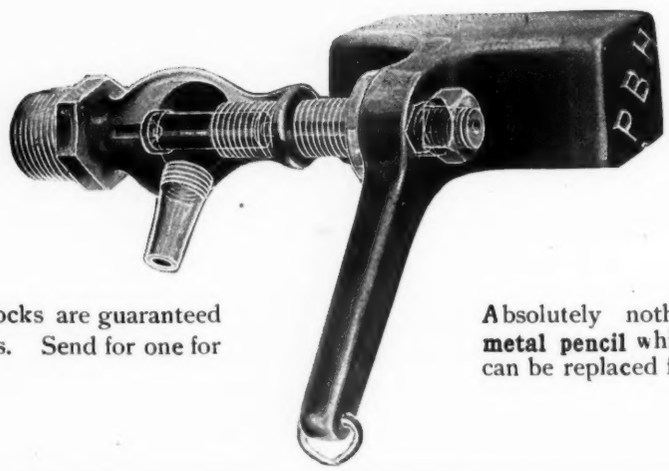
The man who uses the old fashioned Water Gauge and takes the scalding, par boiling consequences is bold—no doubt of it—but what about his judgment?



The "P.B.H." Quick Closing Water Gauge.

THE HUYETTE WAY!

Be wise and remember that discretion is the better part of valor. Install the **"P.B.H." Quick Closing Water Gauge** and put your valor to better use Let your judgment have a chance to protect you from being foolhardy.



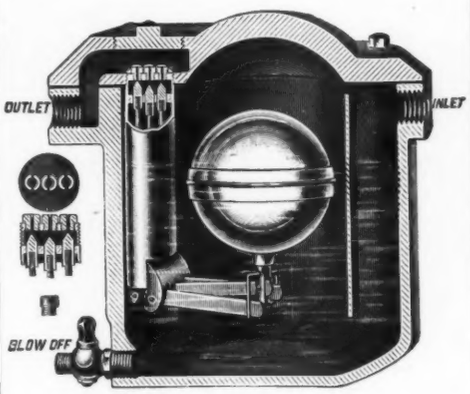
"P. B. H." Gauge Cocks are guaranteed **LEAKLESS** for years. Send for one for a 60-day trial.

Absolutely nothing to wear, except **metal pencil** which lasts for years and can be replaced for a few cents.

THE PAUL B. HUYETTE COMPANY, Inc.,

2025 Betz Building, Philadelphia, Pa.

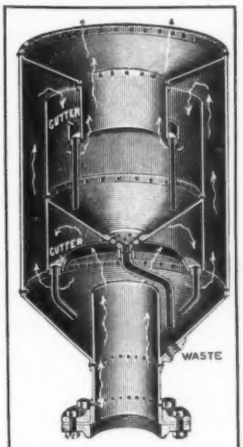
WRIGHT STEAM SPECIALTIES



"EMERGENCY" STEAM-TRAP

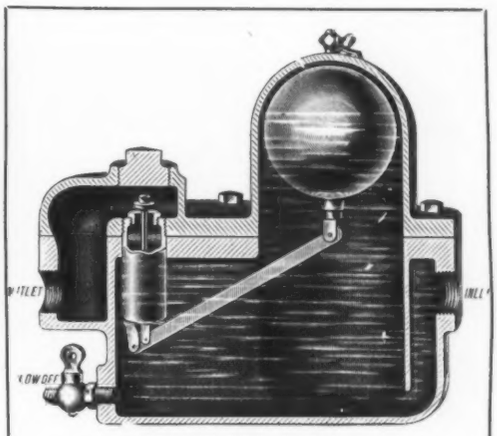
For High Pressures—Up to 250 Lbs.

We want to ship this Trap to you for thirty days' trial at our risk. THREE VALVES in the "EMERGENCY" provide greater capacity than any other trap now made for high pressure duty. WATER SEAL prevents steam waste. Valves are located in highest part of trap away from dirt, etc. By unscrewing a plug in top, valves may be easily inspected or removed. If the "Emergency" fails to keep the steam lines drained of condensation, return it at our expense.



"CYCLONE" EXHAUST-HEAD

keeps the oil and water from exhaust pipes from spraying on roofs, walls, sidewalks, etc. Muffles the sound of exhaust steam. Great internal area makes "back pressure" absolutely impossible. Constructed of extra heavy galvanized steel plate, it is practically indestructible. Perfect operation guaranteed.



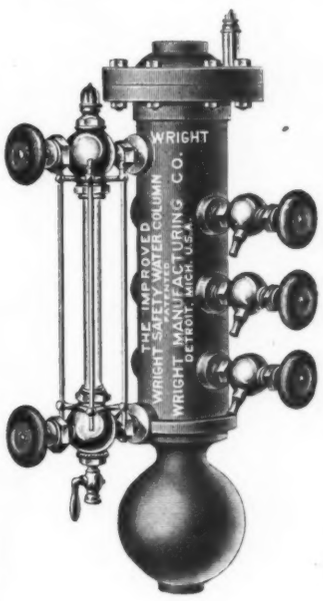
"VICTOR" STEAM-TRAP

For Low Pressures—"0" to "20" Lbs.

Try one for that heating system; see if you don't get better results at less cost; ONE LARGE VALVE under low, or NO pressure, will discharge the small flows or floods of condensation automatically, instantaneously and without steam waste. This Trap is in universal use, saving thousands of dollars to satisfied customers, many of whom we are at liberty to name. If you wish a good low pressure trap, one absolutely guaranteed, let us ship you one or more "VICTORS" at our risk.

ONE VALVE
ONE FLOAT
ONE WHISTLE

Approved by all Government and State Inspectors.



SIMPLE
ECONOMICAL
DEPENDABLE

Shipped Anywhere Subject to Approval.

Every appliance we sell is shipped subject to thirty days' trial and return at our expense of transportation, both ways, if results are not satisfactory.

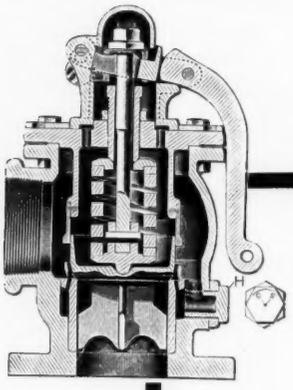
We maintain an expert Engineering Department, the services of which are at your disposal at any time in connection with the application of our specialties.

WRIGHT IMPROVED SAFETY ALARM WATER COLUMN

Send for our illustrated Catalog—It's free for the asking

WRIGHT MANUFACTURING CO.

DETROIT, MICHIGAN 27 WOODBRIDGE STREET



If You Can See

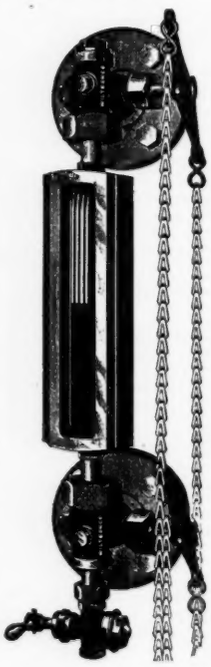
Ashton Nickel Seated Pop Safety Valves on your boilers and Ashton Steam, Vacuum and Recording Gages on your engine room gage board, you know that your power plant could not be equipped with more efficient, reliable or durable safety appliances, regardless of expense. No greater economy can be secured than by using Ashton High Grade Fittings. The best engineers specify them exclusively. Send for Catalog "P."

THE ASHTON VALVE CO.,

Boston New York Chicago

St. Johns House, London, E. C.

Reflex Water Gauges



Used By All The Principal Navies Of The World.

For stationary, Marine and Locomotive Boilers this gauge proves—

An absolute protection against injuries to workman, and boiler.

Easily cleaned without disturbing connection and easily applied to existing boiler mountings.

Uneffected by cold air drafts.

The Water Shows Black

Jerguson M'f'g. Co.,

223 Columbus Ave., Boston, Mass.

Successors to Wm. T. Bonner & Co., Engineers and Manufacturers.

"Safety" PLASTIC METALLIC PACKING.

"It does the work"
"It don't wear out"

For Steam, Water, Air, Gas, Hydraulic Machines, Valves, Etc.

Put up in thin cotton tubes 36 inches long, and all sizes in diameter. Also, put up in bulk form, in metal packages of 12, 25, 50 and 100 pounds each.

Highest Award World's Fair, St. Louis.

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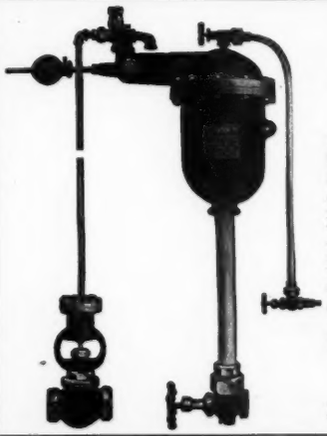


THE VIGILANT FEED WATER REGULATORS

For Steam Boilers

Have the longest and best record of any of these devices. The FULTON PUMP GOVERNOR has no superior. This firm stands for *no misrepresentation*, absolute solvency, and ability to make all its guarantees good. Investigate our standing and send for our latest catalog, with list of users, in which will be found the names of the largest and best power plants and factories in the United States.

THE CHAPLIN-FULTON MANUFACTURING CO.
Pittsburgh, Pa.

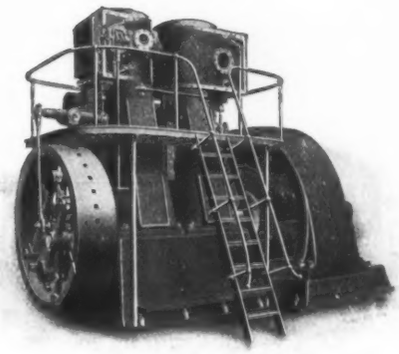
D. W. PATTERSON, Agent,
Harrison Bldg., Philadelphia, Pa

"SHEPHERD" ENGINES

RANK FIRST IN ALL THINGS

There isn't another engine manufactured that possesses the strength, durability, high efficiency and perfect symmetry of line that is manifested in the "Shepherd."

With "Shepherd" Engines, its **strength** that counts—not simply weight. The metal is scientifically distributed in just the places where it is needed most. And every ounce of material is there for the most good. "Shepherd" Engines give perfect satisfaction because



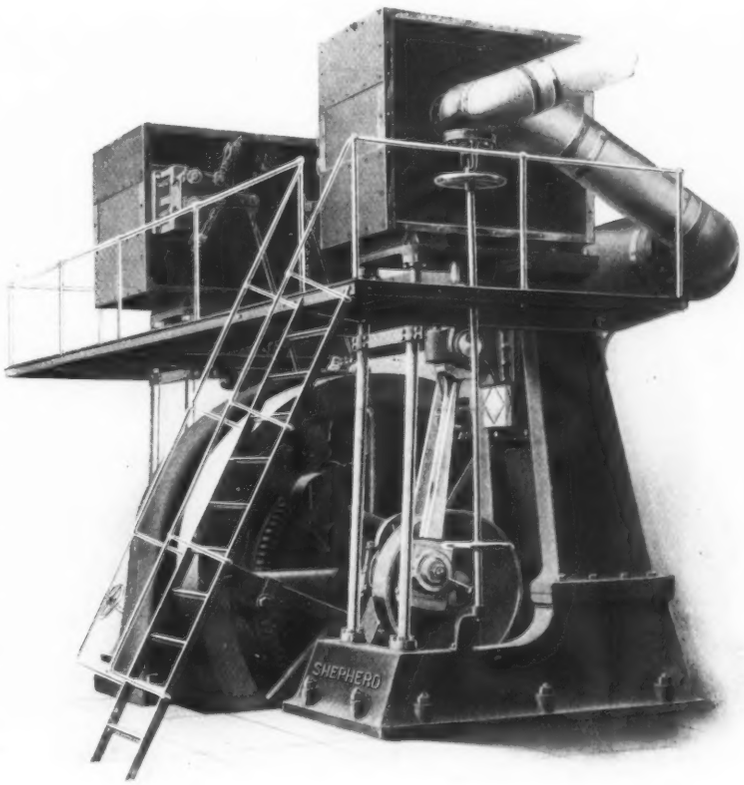
Cross-Compound Single Valve Engine.

THEY ARE ENGINES OF QUALITY

All their parts are made to standard gages under the most careful system of inspection and testing. Only the finest materials are used and our shops are equipped with the latest and best tools and machinery.

Write us YOUR requirements. Our guarantee is sweeping and liberal. We carry all standard engines in stock and are prepared to build others for **any service** from 10 to 2000 H.P.

Write for Catalogs.



Cross-Compound Four Valve Engine.

THE SHEPHERD ENGINEERING CO.,

WILLIAMSPORT, PA., U. S. A.

The Old Man's Sermonettes.

When the lights go out in a colored prayer meeting some addlepated nigger makes a break for the front door, and twenty minutes afterward they carry out the remains of a dozen women and children and lay them along the fence and the broken legs, arms and heads are sent to the hospital.

Nothing is so cowardly as panic, nothing so pitiful as cowardice.

Strong men are entitled to a qualm or two when their lives are at stake. but when they slay and kill, run amuck or go daffy on account of a little money in the bank that they can't get out for a few days, it's enough to make sensible men wish they didn't belong to the same species.

There is a financial disturbance on in New York, and when Wall Street itches the rest of the country scratches. but there is no economic disturbance—nothing chronic.

Crops are not as large as last year, but they are plentiful, prices are good and the farmers' mortgage was paid long ago.

We as a country have grown immensely in the past five years and our people are consuming more and more of our manufactured products.

No one but the statisticians in Washington realize the magnitude of our products—why the hens in Iowa alone produce more market value than all the precious metal mines of Colorado.

There cannot be far-reaching hard times until the man next to the soil is affected.

This flurry is about money—cash—which is possible because all business men still think of *values* in gold and confound credit with cash.

Very little cash is needed in business where checks—certificates of credit—pass current, and a competent clearing house keeps the balances.

The money scare took out of circulation many millions of dollars that is hoarded in vaults, under mattresses and in the long stockings—all this helps to make money scarcer and helps along the fright.

Every man who stood in line for the runs on the different banks contributed largely to the campaign fund of the panic.

Every man who sold his securities at panic prices, robbed himself and helped trample out the lives of a few more women and children.

Every man who hid his money lost the interest it might have earned and contributed more than he could afford to a condition where it could earn little or nothing and stuck a crow-bar into the wheels of industry.

Every man who holds up paying his bills, when he has the money, that he may hoard it against a storm is on the staff of the chief rainmaker and the thunder sharp.

The whole country is not going to hell because Wall Street has done something naughty. You do not bid your friends good-bye and make your will for a small case of cholera morbus—especially when you know just what gave it to you.

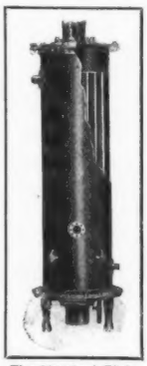
Let the business men of this country go ahead and do business with confidence. Times may let up, but they will not be bad. There will be less boom and more straight hustle. There will be less scramble for anything that can be used and more intelligent seeking for the better things.

The engine building industry is in good shape, there is a let-up in demand, which is not without its blessing and work enough on order to keep the shop going while more is sought.

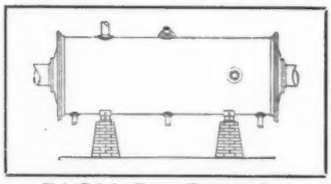
Put your own shop in order, overhaul your old machines, line-up everything from the engine to the counter-shafts. Poke up your salesmen and increase your advertising (in quality as well as quantity), hustle for business a little—it's been hustling for you.

Be optimistic and think of the future some—there is a little gamblers' scare, and a little politics and a great deal of fright by some big corporations that have been disobeying the law in this present trouble. There has been an intermission for the rain. The game is not called—play ball.

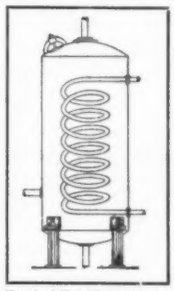
THE OLD MAN.



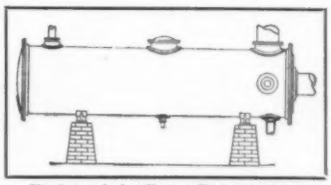
The Standard Plain Tubular Heater



Plain Tubular Heater, Horizontal Type



Vertical Hot Water Tank, With Round Coil

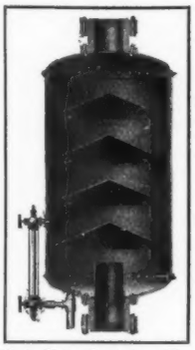


The Steam Jacket Heater, Horizontal Type

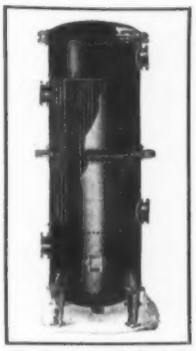
The Steam Jacket Heater

The Baragwanath Army Of Economy Winners

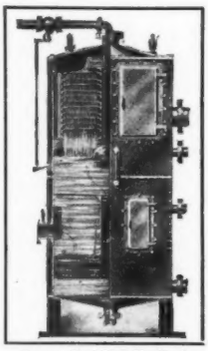
Baragwanath Boiler Room Specialties are fighters against expense and trouble. Their installation invariably results in a lowering of fuel bills, true economy, higher efficiency and beneficial influences felt from one end of the plant to the other.



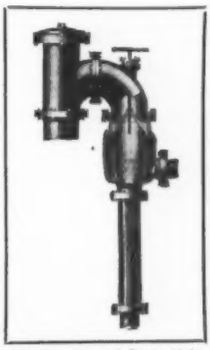
Vert. Steam Separator. For Downward Flow Of Steam



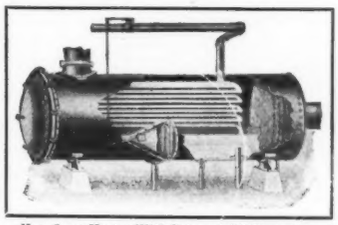
The Baragwanath Vertical Surface Condenser



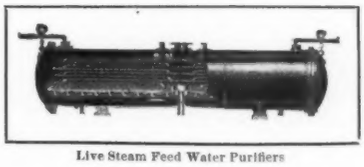
Square Cast Iron Vertical Open Heater



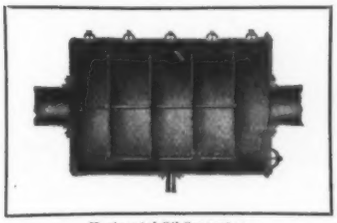
The Baragwanath Barometric Condenser



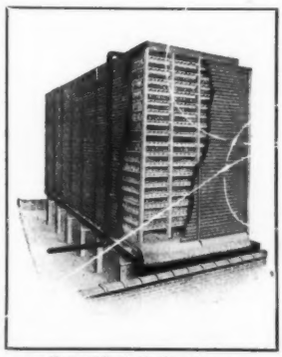
Hor. Open Heater With Interral Oil Separator



Live Steam Feed Water Purifiers



Horizontal Oil Separator



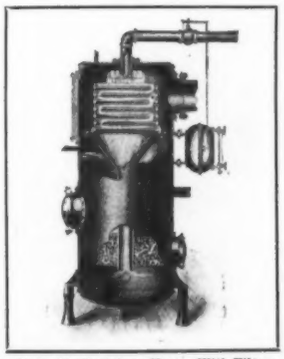
Natural Draft Cooling Tower

SEND FOR A CATALOG

Wm. Baragwanath & Son,

54 West Division St.,

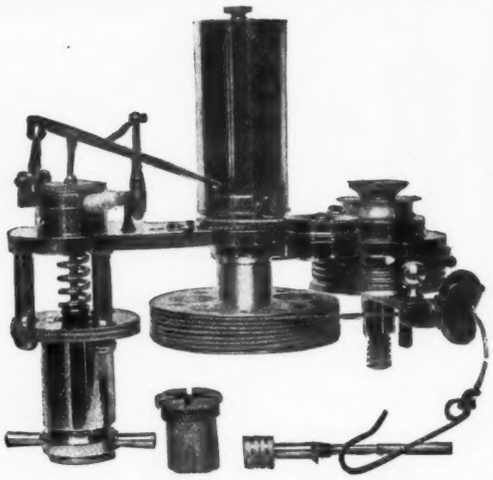
Chicago, Illinois, U. S. A.



Steam Vertical Open Heater With Filter

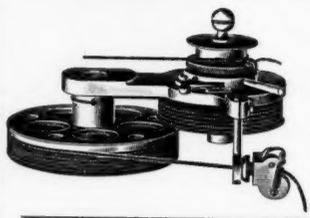
Trill's Latest Triumph:

Outside Spring Indicator.



Lighter moving parts than any other. Cylinder is steam-jacketed, easily removed for insertion of high pressure cylinder. Adapted especially for superheated steam, gas engines and high pressures.

TRILL'S FAULTLESS REDUCING WHEEL



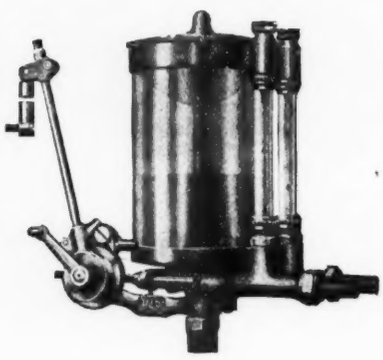
is guaranteed to work on higher speeds than any other. As you know, the best Indicator is useless unless a proper reducing motion is used for the cards. TRILL products are a guarantee for absolute card accuracy.

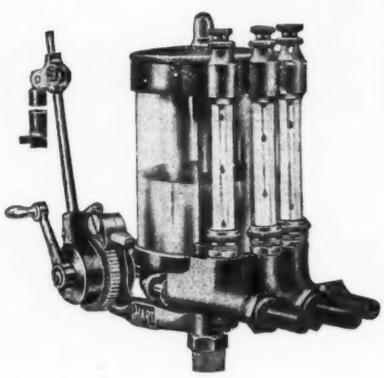
Take the Trill "Triumph" on a Trial Trip and if it does not make you glad it came, and you are not anxious to keep it—return it to us.

Our Indicator Booklet tells the whole story. Send your name.

Trill Indicator Co., EAGLE ST., Corry, Pa., U.S.A.

The "Hart" Force Sight-Feed Oil Pumps





THE BEST AND MOST SATISFACTORY PUMPS
For Positive, Reliable, Uniform and Economical Lubricating.

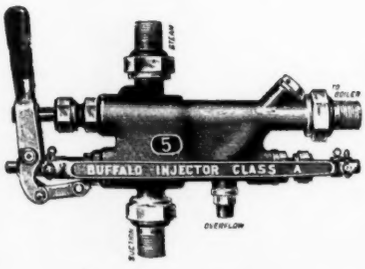
Catalogue and Prices sent on Application.

MANUFACTURED BY

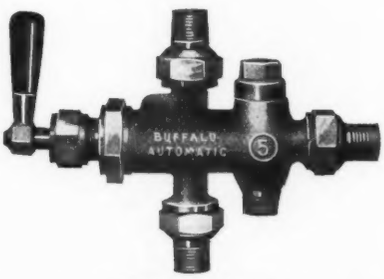
Sherwood Mfg. Co.,
Buffalo, N. Y.

Manufacturers of Engine and Boiler Supplies.

Injectors, Ejectors, Gauge Cocks, Boiler Tube Cleaners, Flue Scrapers and Blowers, Oil Cups and Pumps, Lubricators, Automatic Oil Pumps, Grease Cups, Special Brass Work.



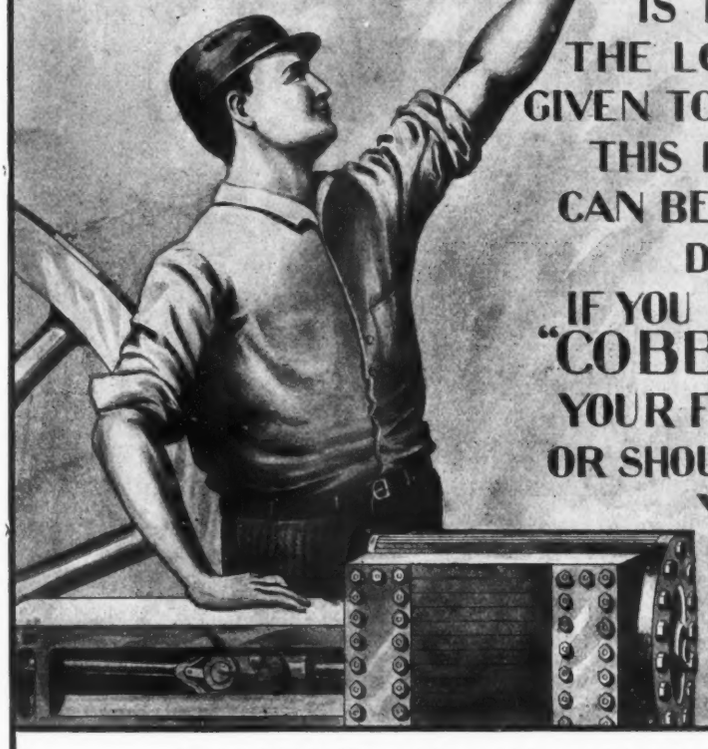
"Sherwood" Injector.



"Buffalo" Injector.

A BOX OF COBBS PISTON AND VALVE ROD PACKING

IS A WELCOME SIGHT TO THE PROGRESSIVE ENGINEER. AS IT IS A " SURE THING " THAT LOTS OF TROUBLE AND HARD WORK WILL BE AVOIDED BY USING "COBBS PACKING"



THE REPUTATION OF THIS PACKING IS THOROUGHLY FOUNDED. THE LONG AND SUCCESSFUL TESTS GIVEN TO "COBBS" HAVE ESTABLISHED THIS BEYOND QUESTION. NOTHING CAN BE SAID OR DONE THAT WILL DETRACT FROM IT.

IF YOU DO NOT KNOW THE VALUE OF "COBBS PACKING" ASK ONE OF YOUR FRIENDS WHO HAVE USED IT OR SHOULD YOU WANT US TO SHOW YOU WE CAN DO IT.

WE HAVE THE EVIDENCE.

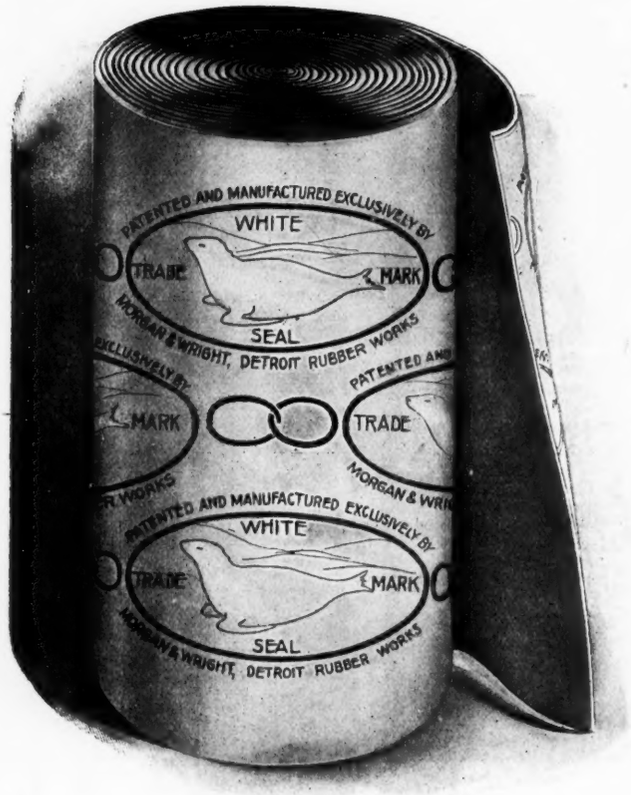
PATENTED AND MANUFACTURED SOLELY BY THE

NEW YORK BELTING & PACKING CO. LTD.

91 & 93 CHAMBERS ST., NEW YORK.

CHICAGO, 150 LAKE ST.
PHILA., 118-120 N. 8TH. ST.
BOSTON, 232 SUMMER ST.
INDIANAPOLIS, 229 S. MERIDIAN ST.
BUFFALO, 600 PRUDENTIAL BLDG.
PITTSBURGH, 913-915 LIBERTY AVE.
SPOKANE, 163 S. LINCOLN ST.
BALTIMORE, 114 W. BALTIMORE ST.
ST. LOUIS, 218-220 CHESTNUT ST.
SAN FRANCISCO, E. 11TH ST. & 3RD AVE. OAKLAND

Many Engineers Say that White Seal Packing Helps Them to Keep Their Plant in Good Running Order.



How About You?
Send for Sample.
Use Attached Coupon.

We claim that

WHITE SEAL

is one of the best Sheet Packings made, and is the only packing that can be carried in stock for months without cracking or deteriorating.

Specially adapted for joints where high steam pressure is used. Will make a perfectly tight air, steam or cold water joint. Is not affected by oil, ammonia or alkali. Does not become soft and will not melt under high temperature. Does not become hard or brittle.

Name .....

With .....

Street address .....

City .....

wants a sample of
White Seal Packing
for inspection.
P

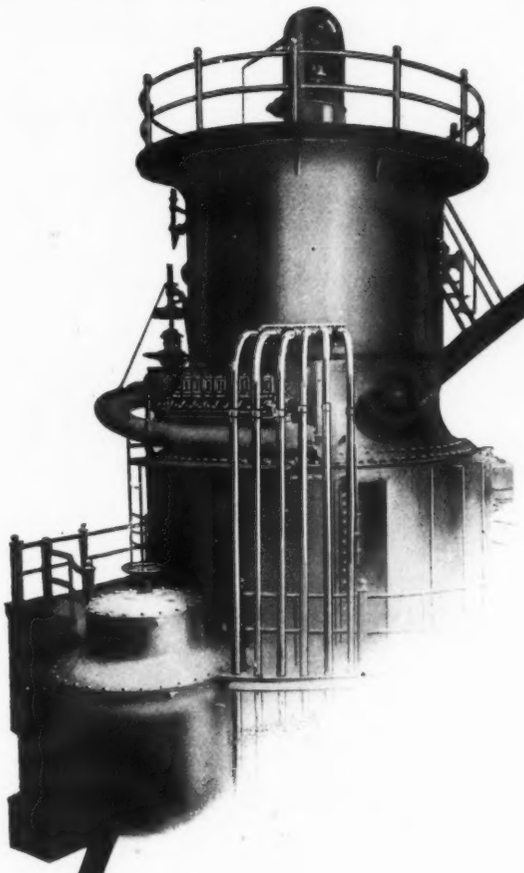
Morgan & Wright

Detroit, Mich.

McMaster-Carr Supply Co.

174-176 Lake St., Chicago

WESTERN SELLING AGENTS



STEAM TURBINES
SUPER HEATERS

are developments of steam engineering that demand a rod packing better than that used in the past to meet the more exacting conditions of the higher development.

PALMETTO

Packing meets these conditions perfectly, because it contains no vegetable fibre, and cannot char nor burn. Thorough lubrication keeps it soft and pliable in service.

Send for a FREE sample.

GREENE, TWEED & CO.,
MANUFACTURERS
109 DUANE STREET
NEW YORK

REVERE PACKINGS

Just a minute, Mr. Engineer. Are you acquainted with the distinctive features of Revere Packings?

Made complete as regards every detail in the Revere factory, thus assuring a uniform product.

The material is the best obtainable and our methods of construction, cutting, coiling and lubricating are the results of years of experience.

Our list is complete. We are prepared to furnish packings to meet any conditions.

We furnish various combinations of packings for unusual conditions.

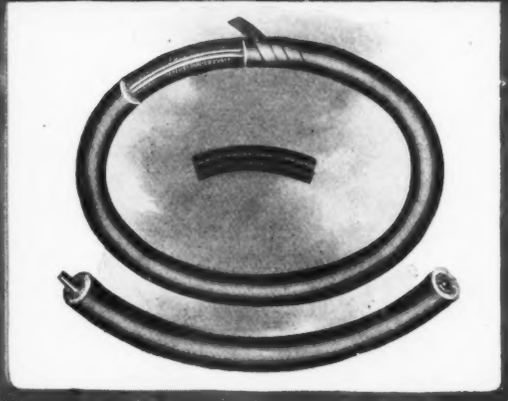
Why not try a set of Black Hawk High Pressure and Revere Stitched Rings on your high pressure piston?

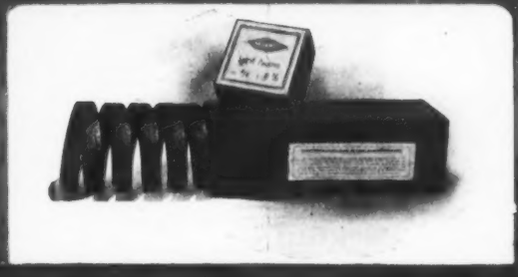
We have different combinations for all styles of plunger pumps. Let us hear from you.

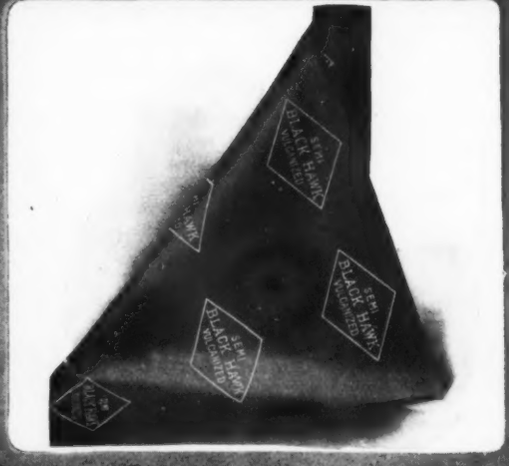
Branches—New York, Philadelphia, Pittsburg, Chicago, Minneapolis, New Orleans, San Francisco, Portland, O.

REVERE RUBBER CO.
77 Bedford St. Boston, Mass.

REVERE PACKINGS





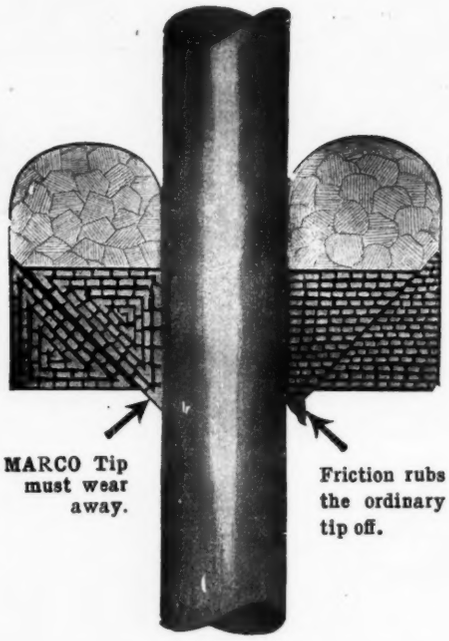


REVERE RUBBER CO.
77 Bedford St. Boston, Mass.

MARCO Diagonal

works equally well on

Water, Air or Steam



Tip Can't Rub Off

but must wear away

Thread by Thread

There are many kinds of diagonal packings on the market, but like everything else, there is but one best—there *can be* but *one* best of any *one thing*.

TRADE MARK

MARCO

REG. IN U.S. PAT. OFF.

U. S. Patent, June 11, 1907.

Diagonal Packing has proved itself to be the best diagonal Packing ever made, not only because the very best of materials are used in its construction, but because its construction is a distinct improvement on the old way of making.

Note that the wedges in MARCO Diagonal are made of one ply of duck wrapped about itself, vulcanized together by the best of rubber, frictioned entirely through the fibres and then moulded wedge shape. Consequently the tip CAN'T rub off or peel, but must wear away thread by thread.

MARCO Diagonal has a cushion of the best braided flax thoroughly lubricated—the entire combination being encased in a braided wrapper and heavily graphited inside and out.

MARCO Diagonal *cannot* go to pieces in the stuffing box.

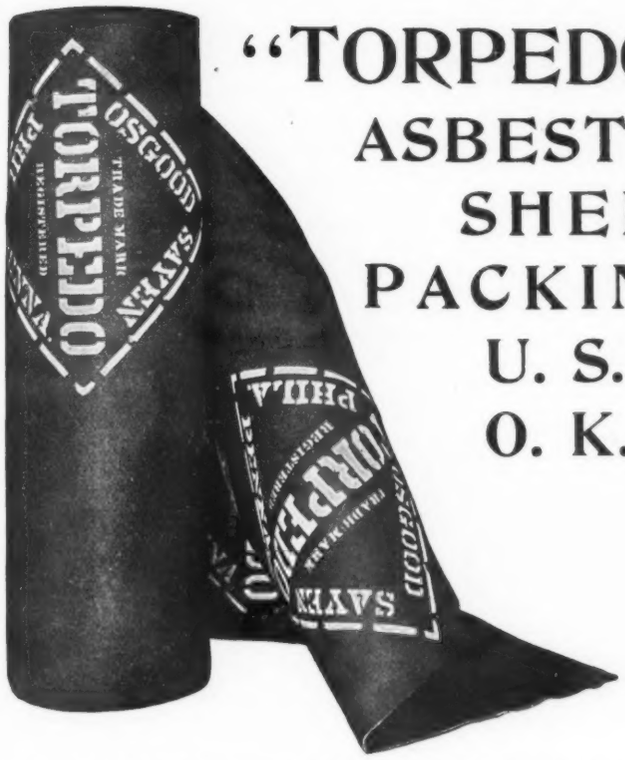
Why not make a trial of MARCO Diagonal, and find out for yourself its real value. Write us anyway for our catalogue and further information.

THE CLEVELAND RUBBER WORKS

of

THE MECHANICAL RUBBER COMPANY

68 Lisbon Street, Cleveland, Ohio



"TORPEDO" ASBESTOS SHEET PACKING U. S. O. K.

U. S., O. K. is a degree of which any packing would be proud, for it means a packing that has satisfactorily passed the hardest test to which it could be subjected.

The United States engineers have tried packings of every sort for use on Torpedo boats. The "Torpedo" stood the test, and that is how it got its name.

"Torpedo" Packing is composed of the best heat-resisting RED rubber compound, asbestos fibre and brass wire. It will make tight joints where all others fail and is so firmly compressed as to be one solid mass. You can keep it in stock indefinitely without fear of injuring its efficiency.

Made in two grades: U. S. Special—hard and tough, and Best Commercial—soft and flexible.

We can supply you with any kind of packing. Get our new Catalogue of Sheet and Rod Packings.

Osgood Sayen,

421 Arcade Bldg., PHILADELPHIA, PA.

DELAMAR'S COPPER REFINING CO.

H. A. PROSSER, General Manager. (A—1001).

LAWRENCE ADDICKS, Superintendent.
Chrome, N. J., Sept. 12th, 1906.

SMOOTH-ON MANUFACTURING COMPANY, Jersey City, N. J.

GASKETS.

Gentlemen—Replying to your inquiry of Sept. 11th, the SMOOTH-ON Coated Corrugated Gaskets which we installed throughout our high pressure piping have been entirely satisfactory, and have been the only gaskets which we have found so far which will stand both superheated and saturated steam applied alternately. We have had our superheater out of service several times since the pipes have been put in commission, and no leaks have developed.

Yours truly,
(Signed) LAWRENCE ADDICKS, Superintendent.

ADX—E. J. B.

Send for illustrated catalog and prices of the Smooth-On Specialties.

SMOOTH-ON MFG. CO., 572-574 Communipaw Avenue, JERSEY CITY, N. J., U. S. A.

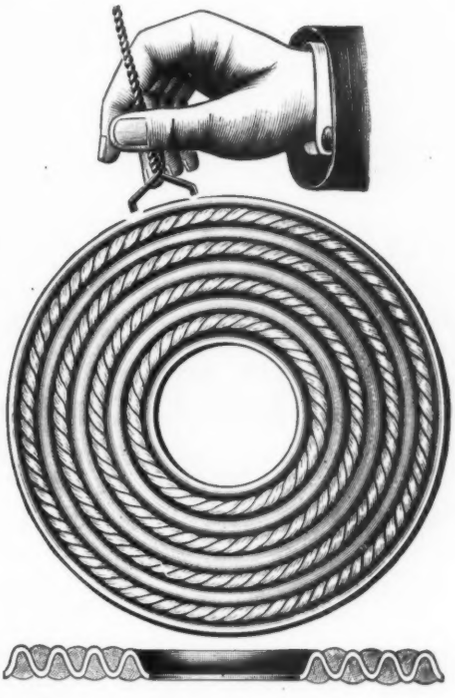
Chicago Warehouse, 61 N. Jefferson Street.

San Francisco Warehouse, 20 Sacremento Street.

"Rex" Metallic Engine Packing Is King Of Them All

It is a packing that really PACKS. It is a packing that is always ready for instant use, and can be used over and over again. There's not another packing that can begin to compare with it. It is safe, reliable and steam tight, guaranteeing perfect results under the highest pressures.

"Rex" Packing is the IDEAL packing for stuffing boxes. It comes in the form of shavings, and every particle can be used—there's no waste. Durable, self lubricating and cheaper in the end than any other.



Goetze's Elastic Copper Gaskets

supply the demand for an absolutely reliable and highly efficient packing. They make leaky joints nothing but a bad memory; stand superheated steam, sudden changes in temperature, and may be used many times with splendid effect.

Mr. Earle F. Scott, M. Am. Soc. M. E., in describing the modern power plant of the Gulfport and Mississippi Coast Traction Co. says of them, "Goetze's Corrugated Copper Gaskets are used and during one year's continuous operation not a joint has required attention." That's proof. Write for details.

American Goetze-Gasket and Packing Co.

527 East 149th Street, - New York City

TRADE MARK
N.I.R.

RED SHEET PACKING

N. I. R.
MECHANICAL
RUBBER GOODS

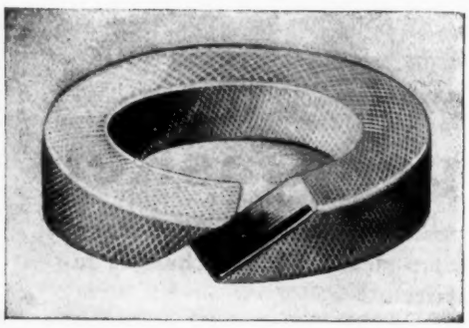
Factory: BRISTOL, R. I.

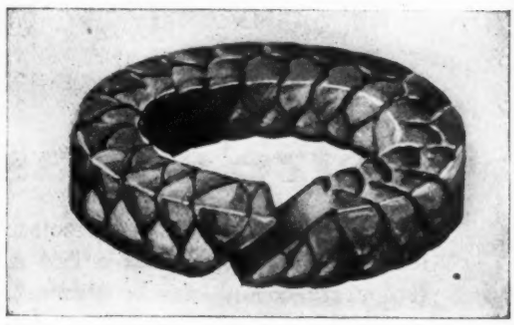
Branches: 42 Broadway, NEW YORK. 84 Lake St., CHICAGO.
101 Milk St., BOSTON. 37 Hopkins Pl., BALTIMORE. 379 Washington St , BUFFALO.

NATIONAL INDIA RUBBER CO.

MATERIAL IMPROVEMENT

IN MANUFACTURING METHODS AS WELL AS IN THE MATERIALS MANUFACTURED

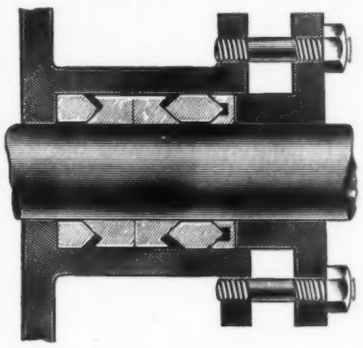




We will let you into the secret of our process—the best materials, the most expert labor, and equipment modernized to the hilt.

Our catalog is a valuable hand book. Shall we send it ?

THE HENRY JOHNSON COMPANY,
186-190 GATES AVENUE,
JERSEY CITY, - - NEW JERSEY.



Law Metallic Packing
Will Increase Efficiency In Your Plant

because it does not have a frictional bearing upon the rod the *whole depth* of stuffing box. Again, isn't a packing that permits of lubrication, and is surrounded by condensation and oil, less liable to cause trouble? *That's Law Metallic Packing.* Can't you see how the adoption of such a packing leads to *increased efficiency?* Its first cost is the only cost—*economy* follows as a natural result.

WRITE FOR THE BOOKLETS.

THE BRIDGEPORT METALLIC PACKING CO.
628 Railroad Ave., BRIDGEPORT, CONN.

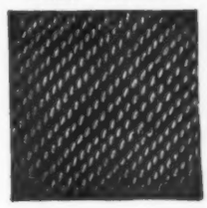
THE PACKING WITH REAL HOLDING QUALITY

DODS Diagonal Piston Rod Packing

is all one piece, made from high-grade Rubber and Duck in layers placed at a diagonal from every side. This construction gives "Dods" across expansion of 100%. It will hold steam, air or liquids when all other packings fail. Send for test samples and description. Address Dept. P.

CROSS-SECTIONS OF

"DODS" PACKING.



ORDINARY PACKING.

☞These Cross-Section Views Show Why!

CHICAGO. **BOWERS RUBBER WORKS** SAN FRANCISCO.

DEMAND to be shown this brand—or the old Century trademark of the cross—on the packing you buy being assured thereby that it is impossible to procure better packing at any price; also that you have bought positive steam joint security. This trademark and the one formerly in use appear only on

CENTURY

CENTURY
White Sheet Packing

and signify supreme quality in every respect. Century Packing is made of very superior rubber and asbestos of equally high grade. Greatest pressure of superheated steam never causes it to stick to the flange, blow out, melt or rot. Storage for months has no deteriorating effect on its superfine quality.

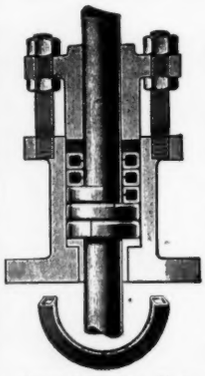
ASK YOUR SUPPLY HOUSE.
Write for information about this and kindred material.

PENNSYLVANIA RUBBER COMPANY,
Jeannette, Pa., U. S. A.

NEW YORK—1741 Broadway.
CHICAGO—1241 Michigan Avenue.
PHILADELPHIA—615 N. Broad Street.
ATLANTA, GA.—102 N. Pryor Street.
BOSTON—20 Park Square.

PRC

BUFFALO—717 Main Street.
DETROIT—237 Jefferson Avenue.
CLEVELAND—2134-6 East Ninth Street.
SAN FRANCISCO—512-14 Mission Street.



We install
Huhn Metallic Packing
under a guarantee and can meet every condition where the rod is in good condition.

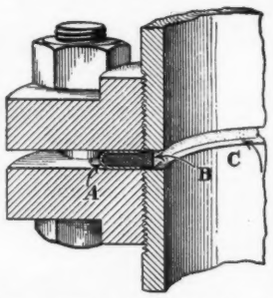
We increase your power by lessening friction.

BOOKLET?

American Huhn Metallic Packing Co.
1876 Broadway, New York.

(Operating under U. S. Patents.)

The Self-Sealing Gasket



The pressure enters the joint at "C," exerts its energy upon the filling "B" forcing "B" into and expanding the U-shaped metal ring "A."

Every gasket guaranteed to give satisfaction or money refunded. Send for descriptive circular and price list.

E. A. WILCOX MFG. CO., 221 E. 63rd St., Chicago, Ill.

American Asbesto-Metallic Packing.

Perfect for high pressure. Semi-metallic, packs like fibrous packing, wears like metallic and gives more satisfaction than either. Ask us just how it is made, or, better yet, get a sample and see for yourself.

American Steam Packing Company,
61 High Street, Boston, Mass., U. S. A.

Mr. Randolph Brandt,
New York City, N. Y

Dear Sir:

Replying to your inquiry as to my experience with the ZENA packings: I have used these packings on Ammonia Compressors, Corliss Valve and Piston Rods, Ammonia Valves, Outside Packed Plungers, Throttle Valves and where a gland packing can be used.

In every place the packing has proved as good as any packing I have heretofore used and in many places better than any.

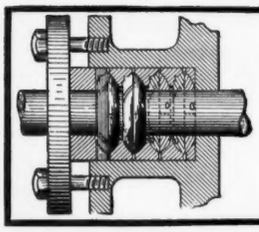
I congratulate you on putting on the market so good a packing.

Very truly,
(signed) Hugh Mooney, Chief Engineer,
James Everard's Breweries Ice Plant.

COPPER GASKETS

We ship at once "Akron" full weight copper gaskets, steel superheat gaskets, lead manhole gaskets and lead ammonia gaskets. Prices right. *CATALOG?*

AKRON METALLIC GASKET COMPANY,
270 Park Street, Akron, Ohio.



Rhodes Improved Metallic Packing Co.,

Guaranteed the Best and Cheapest. Write for Catalog.

149 Broadway, New York.

FREE. Over 500 useful articles given free for coupons which come with every pound of soft or sheet packing and every inch of our metallic packings. All premiums are useful and you take no chances. Premium list is sent on request.

France Packing Co., Inc., Tacony, Philadelphia, Pa.

LEATHER TRADE VIM MARK PACKINGS

Ten Times Longer Wear

Mr. F. J. Helmkamp of Delphos, O., writes us, "As your VIM Leather Packings last about ten times longer than the common kind, I will have sufficient for a long time."

E. F. HOUGHTON & CO.
240-250 W. SOMERSET ST. PHILADELPHIA
173-177 LAKE ST. CHICAGO
98-110 BATES ST. DETROIT.

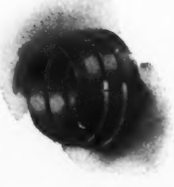
5

The Improved
Tripp Metallic Packing
Manufactured Solely By
Wm. B. Merrill & Co., 74 India St., Boston, Mass.

"Phosphor Bronze"
DELTA
TRADE MARKS REG U.S. PAT. OFF.

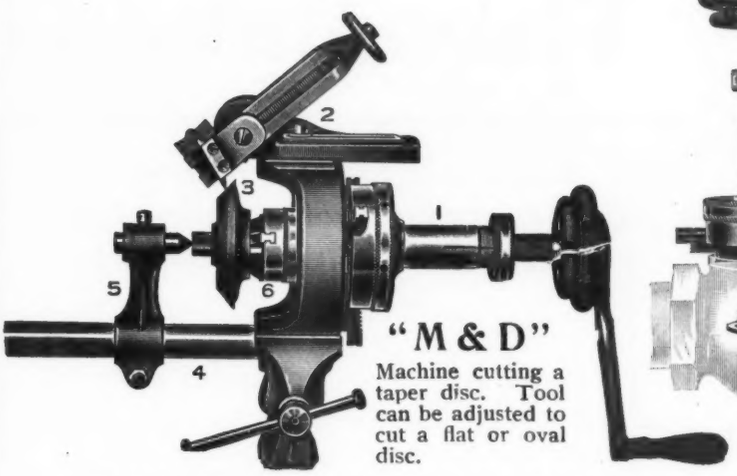
THE PHOSPHOR BRONZE SMELTING CO. LIMITED.
2200 WASHINGTON AVE., PHILADELPHIA.
"ELEPHANT BRAND PHOSPHOR-BRONZE"
INGOTS, CASTINGS, WIRE, RODS, SHEETS, ETC.
—DELTA METAL—
CASTINGS. STAMPINGS AND FORGINGS.
ORIGINAL AND SOLE MAKERS IN THE U.S.

THE UNITED STATES METALLIC PACKING COMPANY.

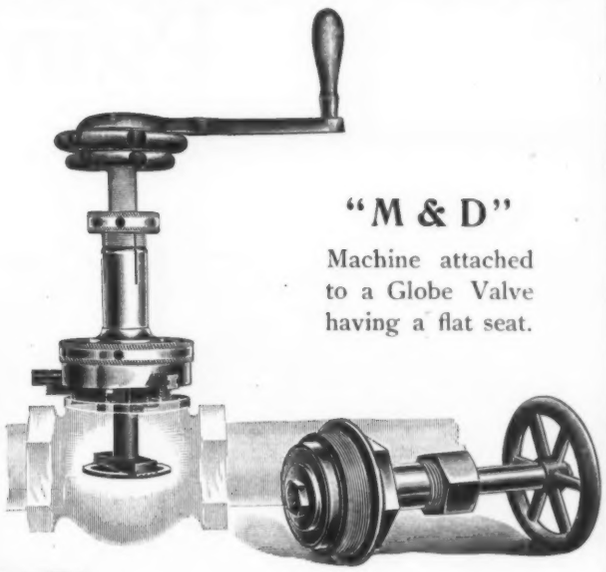


PHILADELPHIA and CHICAGO.

Buried Treasure In Your Scrapheap



"M & D"
Machine cutting a taper disc. Tool can be adjusted to cut a flat or oval disc.



"M & D"
Machine attached to a Globe Valve having a flat seat.

Every discarded valve in your scrap heap can be re-seated and made good and true as new with a MORSE & DEXTER VALVE RE-SEATING MACHINE.

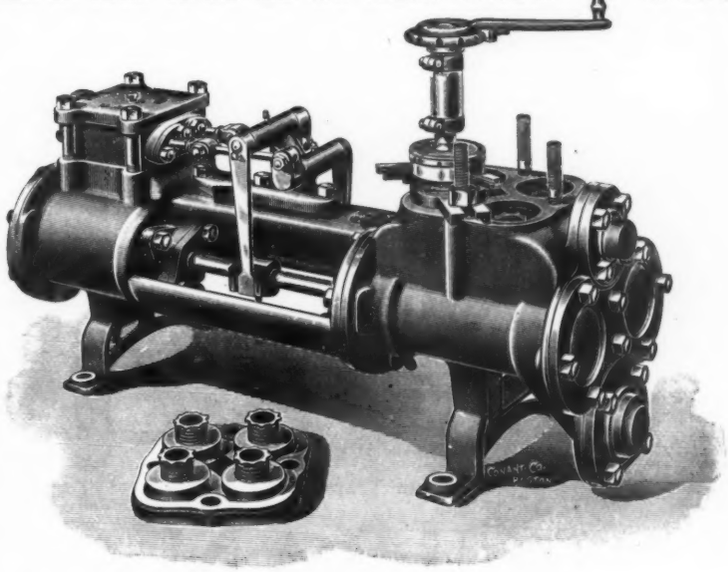
Every valve on your line can be re-seated from 8 to 10 times without disconnecting from the pipe line.

The Morse and Dexter pays for itself so you don't care what it costs but it takes mighty few new valve seats to clear the cost.

You can try it 30 days entirely at our expense, and if in your judgment it fails to be all we claim return it at our expense.

Morse & Dexter Valve.

Machine at work on a Worthington Pump.



Used on every Battleship and in all U. S. Navy Yards— this is Uncle Sam's Guarantee.

Write for Catalog "P"

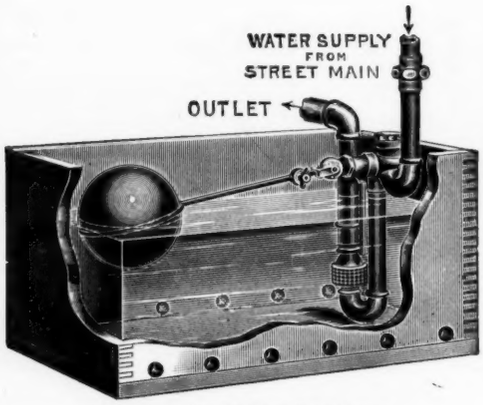
THE LEAVITT MACHINE CO.,

ORANGE, MASS., U. S. A.

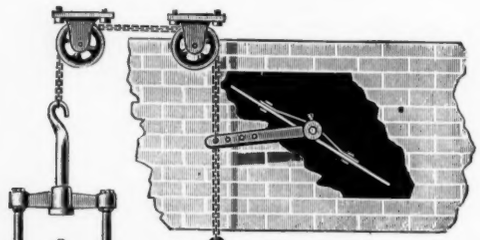
Curtis Engineer=

Point The Way To

They Make The



Automatic Cellar Drainer.



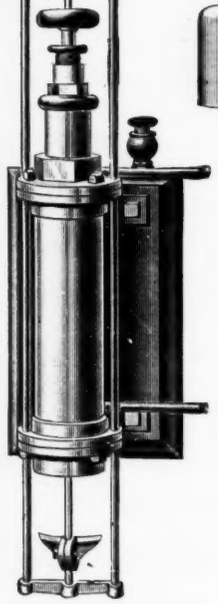
Improved Damper Regulator.

Many plants are at present turning over large profits where they counted only loss under old conditions.

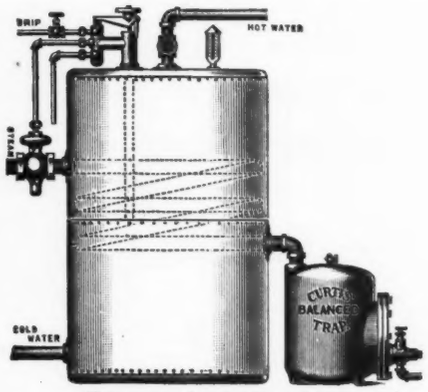
If *you* are laboring under old systems, shake loose and let us teach you how to get *full value* from your steam.

The best proof is test, and actual tests and tabulated results demonstrate and prove the superiority of the **Curtis** Engineering Specialties. Countless satisfied users testify to their merits.

Write For



Return Steam Trap.



Temperature Regulator.

JULIAN d'ESTE

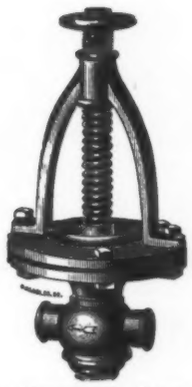
50 Canal Street,

ing Specialties

Greater Economies

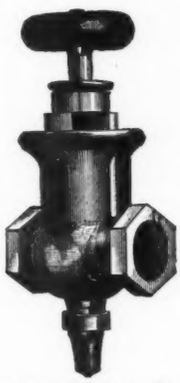
Most Of Steam

Improved Pressure Regulator.
Improved Pump Regulator.
Water Pressure Regulator.
Expansion Trap.
Return Steam Trap.
Balanced Steam Trap.
Relief Valve for Steam and Water.
Damper Regulator.
Separator.
Temperature Regulator.
Tank Governor and Pump.
Air Spring Pressure Regulator.
Cellar Drainer. U. S. Ball Cock.

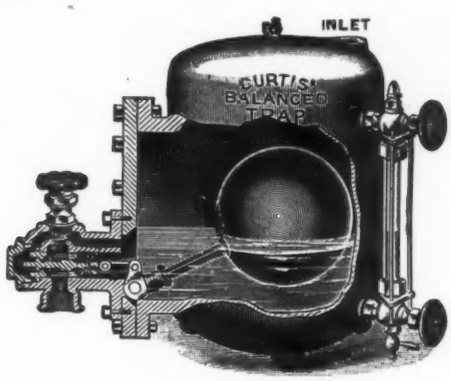


Water Pressure Regulator.

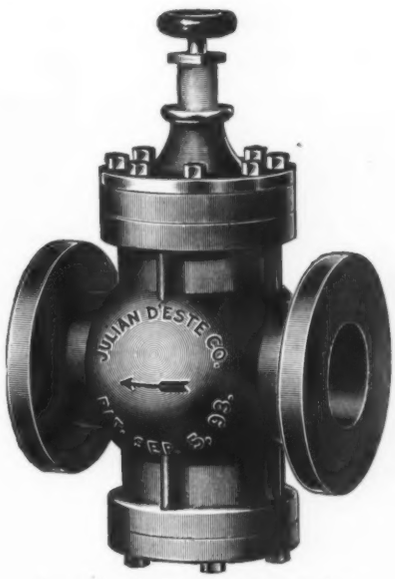
Our Catalog



Curtis Pressure Regulator for Steam.



Balanced Steam Trap.



Improved Steam Regulator.

4 INCH.

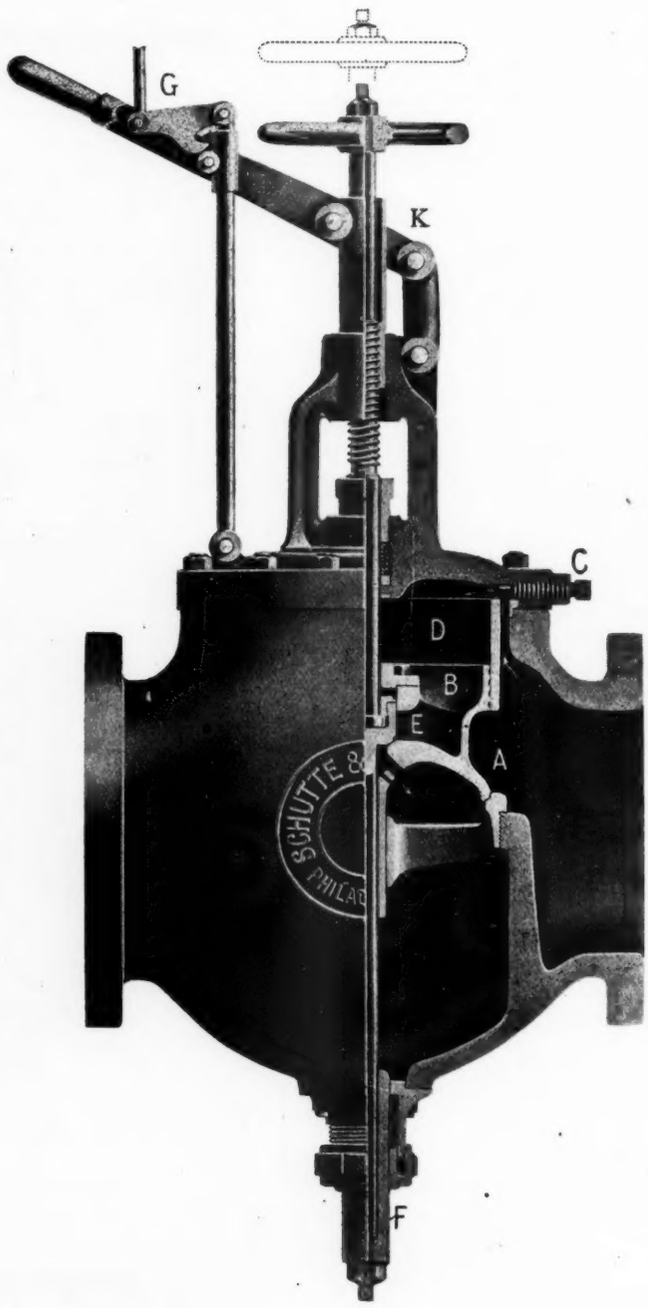
U. S. Ballcock.

COMPANY,

Boston, Mass.

COMBINED THROTTLE AND

QUICK-CLOSING BALANCED TRIP VALVE



These valves are frequently used as an Emergency Trip or Engine Stop Valve in connection with Turbines, Rolling Mill, Blowing and other large engines which are fitted with regular throttle valves.

They may be connected for operation by electric solenoid and tripped automatically by governor or electrically by a push-button, or direct from operating pulpit by wire pull, as deemed most suitable by requirements.

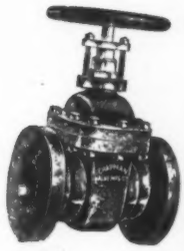
When locked up by latch they can be operated by hand as screw-spindle throttle valves. The screw is carried by sliding trunnion "K". This trunnion is connected by lever, and when latched, forms a rigid connection with yoke—valve is now free to operate by hand-wheel and screw. When partly or fully open, it may be instantly closed by tripping the latch "G".

VERY IMPORTANT SAFETY DEVICE.

SCHUTTE & KOERTING COMPANY,

New York Boston PHILADELPHIA Chicago San Francisco

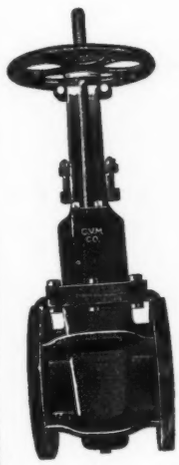
The Solid Wedge Valve Increases Power Plant Profit

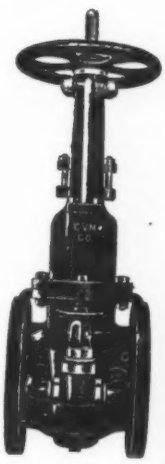


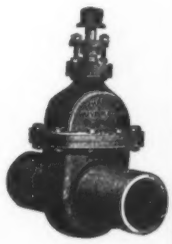
Our solid wedge valves have become world famous through their world wide distribution and satisfying service.

We make Gate Valves and Fire Hydrants in all styles and sizes for hand, hydraulic or electrical operation. Owing to our splendidly equipped plant, orders requiring special designs are subject to the least possible delay.

Write us regarding your needs.







Chapman Valve Mfg. Co.

Indian Orchard, Mass., U. S. A.

BRANCH OFFICES:

Boston, 94 Pearl St.
New York, 28 Platt St.
St. Louis, 16 So. 12th St.
Pittsburg, 914 Farmers Bank Bldg.
Chicago, 1331 Monadnock Bldg.
Philadelphia, 1011 Filbert St.
San Francisco, 63 First St.
London, 147 Queen Victoria St.
Paris, 54 Boulevard Du Temple.
South Africa, Johannesburg
Canada, Jas. Robertson Co., Ltd., Montreal, Can.
Italy, Pietro Ferrero & Co., Turin, Italy.

CAREFULLY EXAMINE

THIS SECTIONAL CUT OF A

LUNKENHEIMER "POP" SAFETY VALVE

NOTICE :-

—The generous proportion of even the smallest detail and the total absence of complicated parts.

—That the spring and top of disc are encased, thereby preventing contact of the spring with the steam, and also keeping the pressure from off the top of the disc.

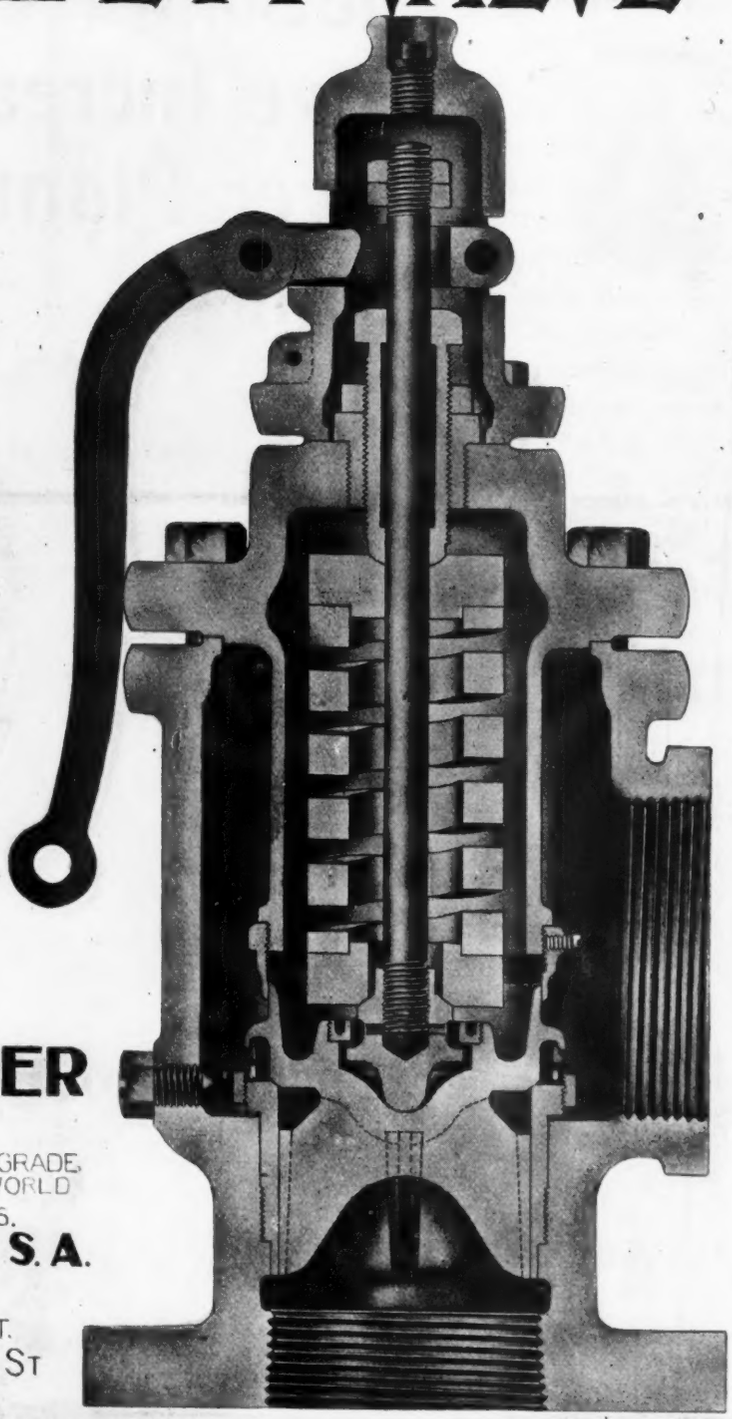
—The large steel spring and that plates holding the spring have ball and socket joints, insuring perfect alignment.

—The large aera within the body permitting of the free escape of steam.

—The large wing guides on the disc. which insures the proper seating of the disc and prevents chattering.

—That the seat has an angle of 45 degrees, and that there is no possibility of sticking.

—That they can be had entirely of brass, or iron body brass mounted, for pressures up to 250 pounds per square inch.



THE USER CAN TELL YOU ABOUT THEIR RELIABILITY.

THE LUNKENHEIMER COMPANY

LARGEST MANUFACTURERS OF HIGH GRADE ENGINEERING SPECIALTIES IN THE WORLD

GENERAL OFFICES AND WORKS.

CINCINNATI OHIO. U.S.A.

BRANCHES

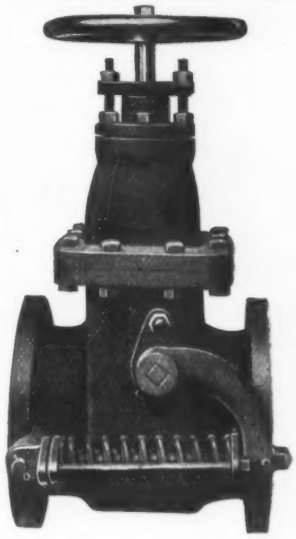
NEW YORK 66-68 FULTON ST.

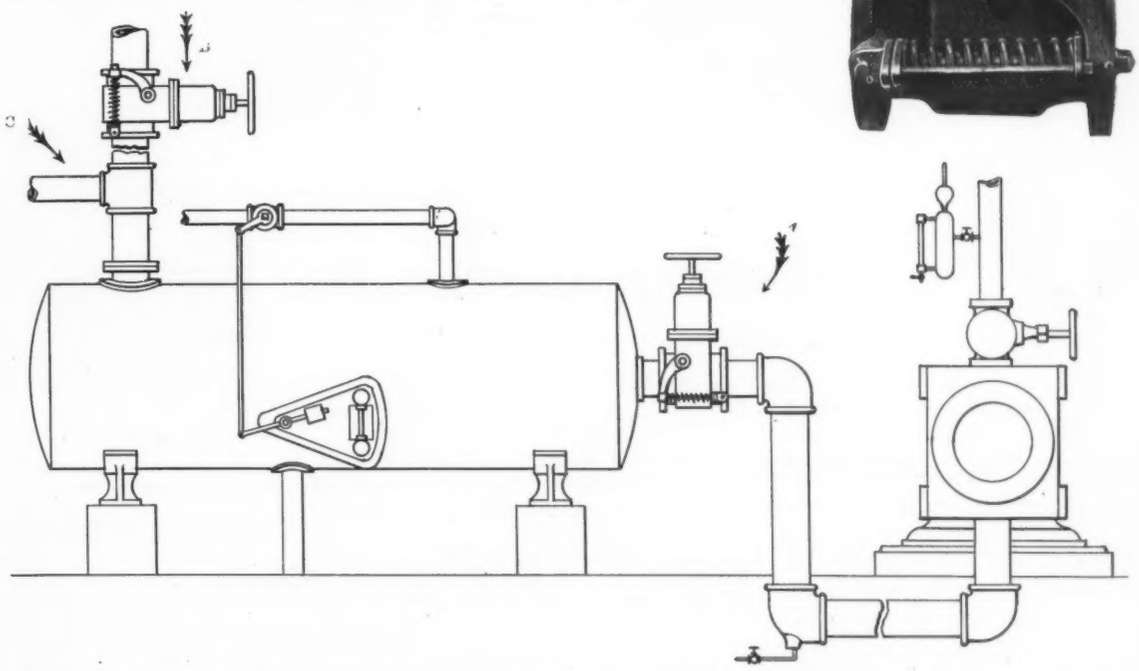
LONDON, S.E. 35 GRT DOVER ST

WRITE FOR CATALOGUE.

The Erwood Swing Gate Valve

As a Safety Non-Return on Condenser and Heater Connections





THIS application of the Erwood Swing Gate in Open Heater connections will attract attention, as it removes an ever threatening danger to any engine connected to exhaust through or into an open heater. **A** is an Erwood Swing Gate Valve connected to an open heater through which passes all or part of the exhaust of an engine. It is kept closed at all times and thus eliminates the danger feared by all engineers, of a flooded heater, backing up into the engine and wrecking it. No open heater can be safely used without an Erwood Swing Gate, located as shown. The danger of flooding is always imminent in open heaters. The Erwood Valve removes this constant menace and admirers of this useful form of feed water heater can now use it with impunity. No other valve accomplishes this purpose. An engine can be started up with the heater flooded with cold water entirely without danger, if an Erwood Valve is used as shown.

¶ The same results are attained with The Erwood Swing Gate on condensing engines. A flooded condenser is no longer a constant menace. The Erwood Swing Gate Valve remedies this as no other device on the market ever has or can. If you try one you will never again connect an engine to an open feed water heater or condenser without using an Erwood Swing Gate Valve.

¶ The Erwood Swing Gate Valve is also adapted to Back Pressure work as shown at **B** on exhaust riser—branch **C** running to heating lines.

¶ The Erwood can be located anywhere and in any position. It is made in one style only. It will operate as well at 1 ounce as at 10 pounds—to the square inch.

¶ The Erwood Swing Gate Valve not only insures the life of your engine but also of your engineer or attendants within reach. Write for illustrated circulars.

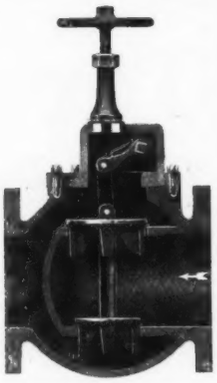
WALCH & WYETH, 87 LAKE STREET, CHICAGO.

PRESSURE REDUCING VALVE.

DAVIS VALVE SPECIALTIES

Will Prove Their Value to You

BEING SOLD STRICTLY ON THEIR MERITS, they must make good or be rejected. There is no chance of your being forced to pay for an inefficient device, for every Specialty that goes out of our factory is on approval. Then we leave you to judge by actual service test whether the GOOD VALUE reputation of **DAVIS VALVES** is true or false. Your interests are protected and we can only hope to secure your business by the unquestionable merit of our goods.

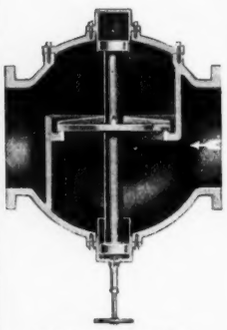


BOILER STOP AND CHECK VALVE.

WE MAKE PRESSURE REDUCING VALVES, EXHAUST RELIEF VALVES, BOILER STOP AND CHECK VALVES, BACK PRESSURE VALVES,

Float Valves, Steam Traps and other PowerPlant Specialties, which are ful described in our new 1908 general catalog just issued. Send for a copy now and select the device you wish to have sent on approval for test in your plant

JOBBERS EVERYWHERE SELL DAVIS VALVES

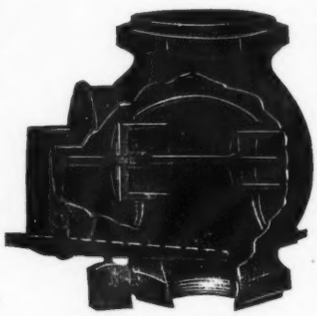


HORIZONTAL EXHAUST RELIEF VALVE.

G. M. Davis Regulator Company,

142 Milwaukee Ave., CHICAGO.

NEW YORK 123 Liberty St. BOSTON 104 High St. ST. LOUIS 735 S. 4th St. SAN FRANCISCO 216 California St. PHILADELPHIA 56 N. 2d St.
PITTSBURGH, 1206 Park Bldg.



NOISELESS BACK PRESSURE VALVE.

One Cost and Only One

We guarantee our valves to remain tight under the most severe conditions.
We would like to tell you why we can afford to guarantee in this sweeping manner.
May we?

NEW BEDFORD BOILER & MACHINE CO.

ESTABLISHED 1872

New Bedford, Massachusetts

Over 500,000 of Kunkle's Patent Lock-up Pop Safety Valves now in actual use.

For Portable, Stationary, Locomotive and Marine Boile.s. They meet every requirement. We also make Mufflers for Locomotives. Write for details and prices.

Fort Wayne Safety Valve Works,

E. B. Kunkle & Co.,

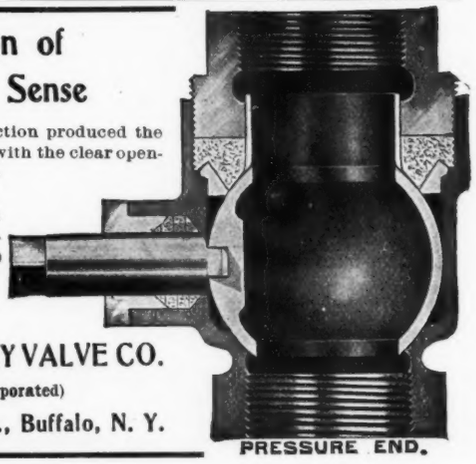
817 Barr St., Fort Wayne, Ind.

Application of Common Sense

to valve construction produced the Huxley, a valve with the clear opening and the perfect closure.

A perfect joint under all pressures up to 200 pounds.

Please mention POWER.



PRESSURE END.

The HUXLEY VALVE CO.

(Incorporated)

145 Main St., Buffalo, N. Y.

YORK MANUFACTURING CO., YORK, PA.

We manufacture all the machinery and parts needed to equip a complete Ice or Refrigerating Plant—Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings of all kinds.
We employ over 1250 men in the manufacture of Ice and Refrigerating machinery exclusively.

CATALOG UPON REQUEST.

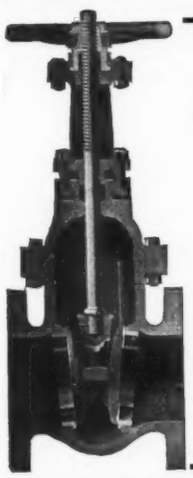
Our fittings carried in stock at the following places: The Ahrens & Ott Mfg. Co., Baronne and St. Joseph Sts., New Orleans, La.; York Mfg. Co., 1060 Monadnock Bldg., Chicago, Ill.; Geo. T. Matthews & Co., 20 S. Main St., St. Louis, Mo.; The F. W. Niebling Co., Highland Ave., Cincinnati, O.; York Mfg. Co., 14 Park Place, New York, N. Y.; York Mfg. Co., 515 House Bldg., Pittsburg, Pa.; Wegner Machine Co., Cor. Perry and Mississippi Sts., Buffalo, N. Y.; United Iron Works, Pacific Coast Agents, 32 Fremont St., San Francisco, Cal.; 231 E. Second St., Los Angeles, Cal., and 109 Main St., Seattle, Wash., also at 610 Raymiller St., Cincinnati, O.

It Pays

No question about it, it pays everyone who has anything to do with valves or pipage equipment to get the best and nothing else. Our products are known the world over as the best that human skill can possibly create. Our catalog will prove for you a great source of information.

Pittsburgh Valve, Foundry & Construction Co.

Pittsburgh New York Boston
Cleveland Birmingham



DOUBLE DISC SELF ADJUSTING NELSON GATE VALVES

In Brass and Iron
For All Pressures.

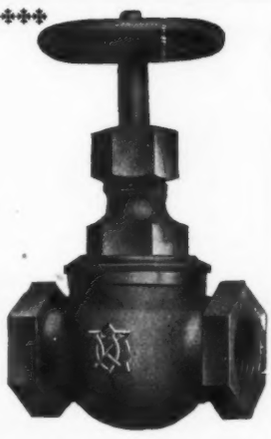
The NELSON VALVE CO.
WYNDMOOR,
PHILADELPHIA, PA.

Star Brass Manufacturing Co.,

Extra heavy, Renewable seat and disc Globe and Angle Valves are all tested to 1000 lbs. cold water before being shipped to customer. They are renewable, in every part, also absolutely leak proof. Made from our special high grade steam metal, and guaranteed for the highest pressures.

Manufactured by
Star Brass Mfg. Company,
108-114 East Dedham Street, Boston, Mass.
Branch Office: 70 Cortlandt St., New York City.

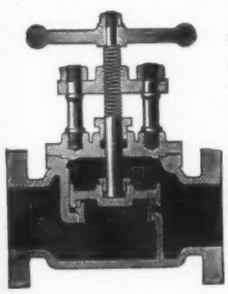
Renewable Disc, Seat Cast Solid To The Body. Hexagonal Recess In Stuffing Box.



Large passageway for steam or fluid. These are a few Kennedy Globe Valve advantages. May we send you the others? *Catalog?*

THE KENNEDY VALVE MFG. COMPANY,
70 Beekman Street, NEW YORK.

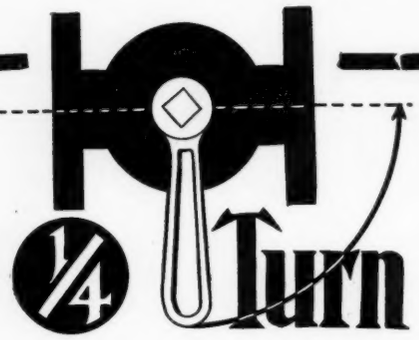
"BELLVILLE" VALVES



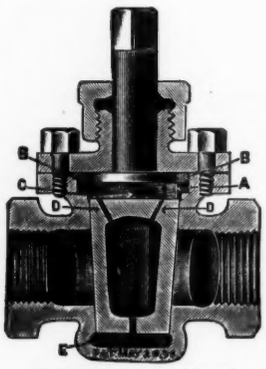
have the seat on the outside of an inverted cone where the direct current of steam does not come in contact with it, preventing all chance of wire drawing. Other features in catalog.

Heavy, Compact, Durable,
no marring by pipe tongs.

Eastwood Wire Manufacturing Company,
Belleville, New Jersey.



Is All That's Needed To Open or Close A HOMESTEAD VALVE



Homestead Straightway
Balance Plug Valve
Locks by Quarter Turn.

The unique features of the *Homestead Valve* make it obviously the quickest acting, simplest, easiest operated and most durable ever made.

The *seat* is absolutely protected from wear when pressure passes through; *plug* is balanced and held in place by pressure when open, and when closed is locked in the seat by our patent wedging cam, insuring *freedom from friction* in seat while plug is turning.

Homestead Valves are made in Straightway, Three-Way, Four-Way, Locomotive Blow-Off, Angle styles, etc.

If you are desirous of getting perfect, lasting valve satisfaction send for our booklet and read all the *"Homestead"* features.

Homestead Valve Mfg. Co.,
BRASS FOUNDERS
Pittsburg, Pa., U. S. A.

The seal of public approval has been stamped on Hercules Floats. They stand for protection in float manufacture and are making good in thousands of plants as you read.

Hercules Seamless Copper Floats

Over 240,000 have been sold in 12 years. This is eloquent praise of their thorough goodness and reliability. Our Catalog "B" will give you many points. Just ask for it.

Hercules Float Works,
P. O. B. 396, **Springfield, Mass.**

The Simonds
Automatic Vacuum Valve

is superior to other kinds because, when not discharging, valves are tight on their seat; as a result, **there's no steam wasted** by being blown through into the vacuum. Water discharge valve is minus guide wings and pins; hence, a free discharge for dirt. Air discharge is above water line in valve, just where the air naturally collects.

Let us post you thoroughly on the subject.

Simonds Heating & Specialty Co.,
105 Washington Ave., Detroit, Mich.
Makers of Simonds Steam Receiver and Separator.

Advantages of Reliable Water Gauges and Columns

No scalding of hands or destruction of eyesight.

Glass may be taken out and cleaned while under pressure and without loosening stuffing boxes.

Can be subjected to drafts of cold air or very high heat and pressure without danger of bursting.

They are easy to attach and as the stuffing boxes are independent of the glass there is no danger of breaking while tightening them.

Send for Circular.

Reliable Water Gauge Co.
1616 E. Pine St., St. Louis, Mo.

You don't need a tool in packing your gauge glass if you use the

Gilbert Gauge Glass Preserver

It makes a perfectly tight joint, and more than returns its cost. Send 60c for a sample box.

R. F. MORSE, Providence, R. I.

COMPLETE PIPING EQUIPMENTS FOR POWER PLANTS AND BLAST FURNACES
BEST-FITTINGS
BEST MANUFACTURING CO., PITTSBURGH, PA.

PITTSBURGH VALVE AND FITTINGS COMPANY

For 250 Pounds Working Pressure

With By-pass Spur or Bevel Gearing

Outside Screw and Yoke or Non-Rising Spindles

Tested to 800 Pounds

EXTRA HEAVY GATE VALVES

We make all kinds of valves and fittings. See our ad. in The Engineer, Domestic Engineering, Plumbers' Trade Journal, Engineering Magazine, and Southern Engineer.

Address All Communications To
GENERAL OFFICE, FRICK BUILDING
PITTSBURGH, PA.
Works: Barberton, Ohio.

FOSTER VALVES

Class "W"

The Foster Class "W" Pressure Regulator

has neither weights, levers, nor pistons, is very sensitive, may be adjusted for pressure desired, and once adjusted, will maintain a constant uniform delivery regardless of variation in boiler pressure.

Relief or Free Exhaust Valve

The Foster Relief or Free Exhaust Valve

protects a compound engine from the consequence of failure of the condenser and loss of vacuum during the absence of the engineer.

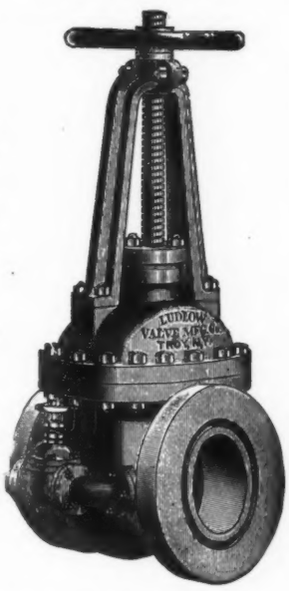
Noiseless, reliable and without parts liable to obstruction from scale or impurities.

We will send our catalog upon request.

THE FOSTER ENGINEERING CO.
NEWARK, N. J.
Room 303, 40 Dearborn Street, Chicago, Ill.
403 Harrison Building, Philadelphia, Pa.

Quality Valves Yesterday--Today--Forever

"Ludlow"



It is this made-a-little better-than-seems - necessary policy of The Ludlow Valve Mfg. Co., that is holding old customers and securing many new ones.

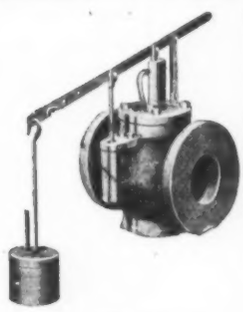
Ludlow Valves are made for the most exacting service—careful tests and thorough inspection before shipment, insures their correctness in every detail when they reach you.

All sizes for every purpose.

Ask for the Catalog.

The genuine Ludlow is made only by

THE LUDLOW VALVE MANUFACTURING COMPANY,
Adams Street, Troy, N. Y., U. S. A.



We Show Here Four

of our many devices.

Back Pressure, Reducing and Blow Off Valves.

We would like to send you our catalog showing complete line of

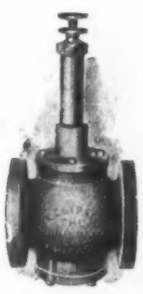
Separators, Steam Traps, Pump Governors, and Regulating devices that Regulate.

SEND FOR IT.

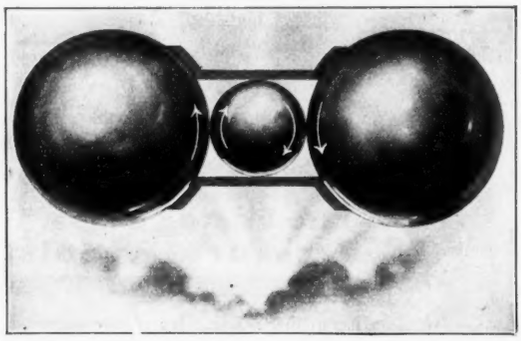
The John Davis Co.,
Chicago, Ill.
22nd, Halsted and Union Streets.
Established 1864.

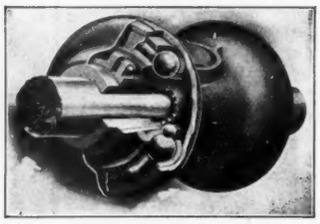
Eastern Representative:
W. G. Ruggles Co.,
54 High St., Boston.

Southern Representative:
A. M. Lockett & Co.,
343 Baronne St., New Orleans, La.



Take Out Your Ring Oiling Bearings and Install The "Chapman" We Guarantee Results

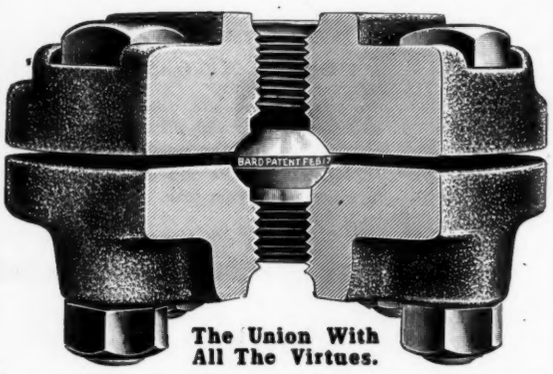




It's easy to cut down coal bills, oil bills and belting provided you awake to the true value of Chapman Double Ball Bearings and install them in your plant. They require no oil, demand no attention and will run for years and years without a thought. Your power CAN'T leak out through them—they work WITHOUT FRICTION. Cool under the heaviest loads.

Write for a Catalog.

CHAPMAN BALL BEARING CO.,
40 Bristol St., BOSTON.



The Union With All The Virtues.

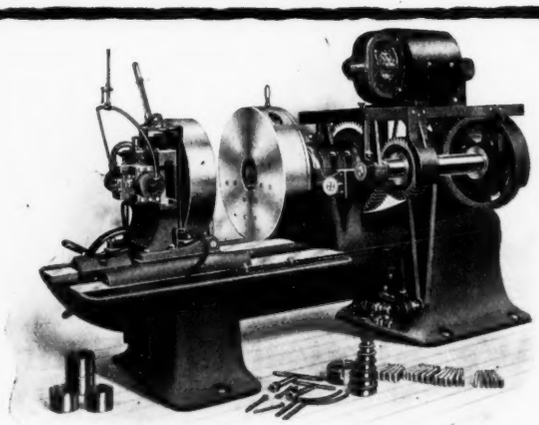
No Flange Can Compete With Bard. It Has So Thoroughly Barred Competition

that where it is once known it is always used to the exclusion of all others.

Catalog ?

The Bard Union Co., Inc.

Norwich, Conn,



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THE E. C. & B. line of pipe-cutting and threading machines, manufactured by Crane Co., possess many exclusive features which greatly facilitate the handling of pipe. These machines are unsurpassed for durability and for rapidity and economy of operation. The line is very complete, ranging from small hand operated tools up to engine, belt on motor-driven machines for handling 18-inch pipe.

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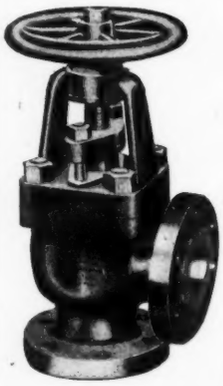

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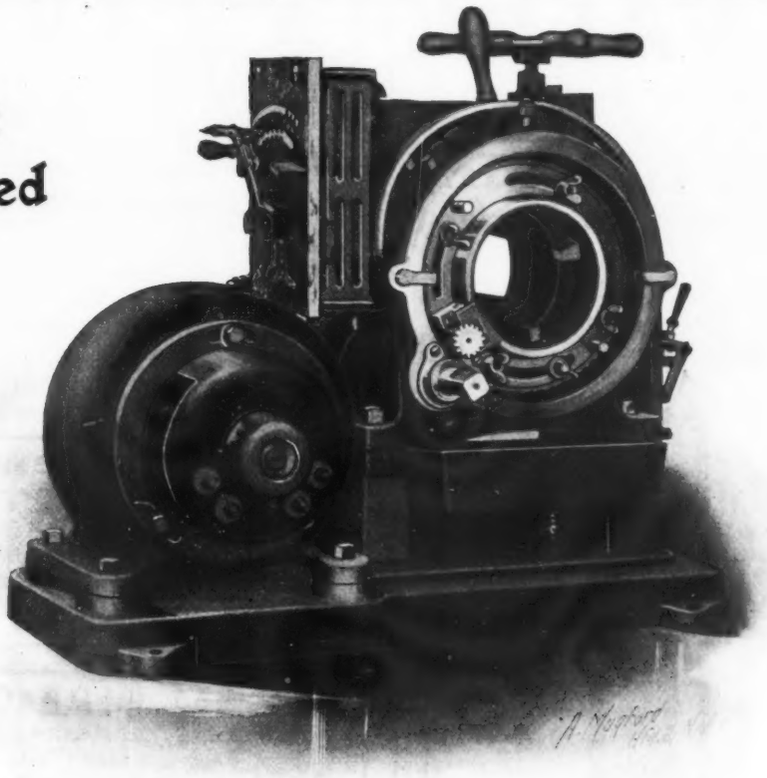

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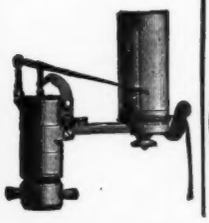

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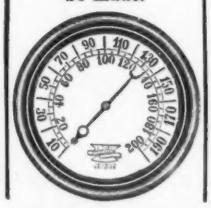

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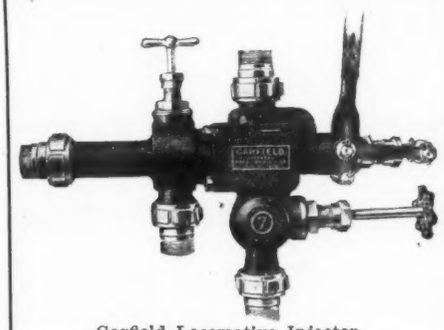
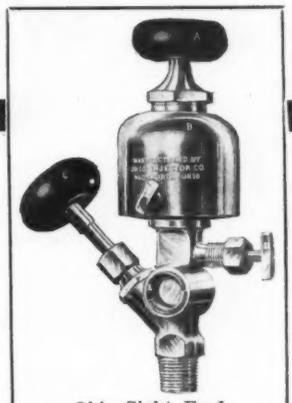


Garfield Locomotive Injector.



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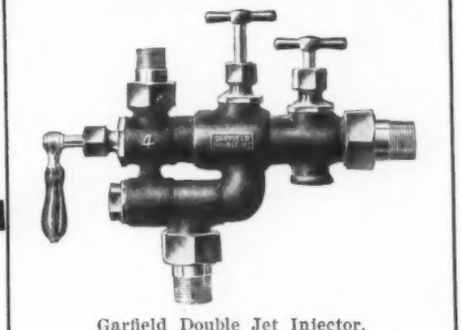

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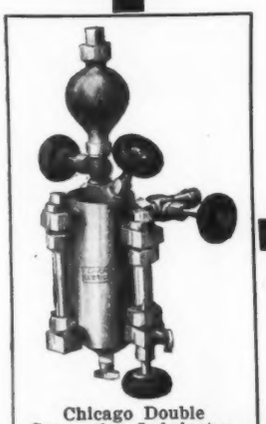
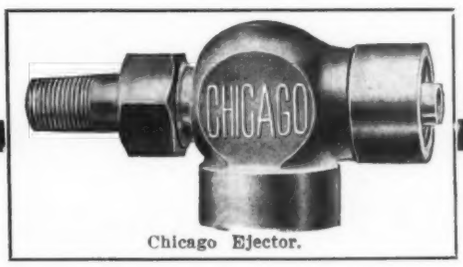
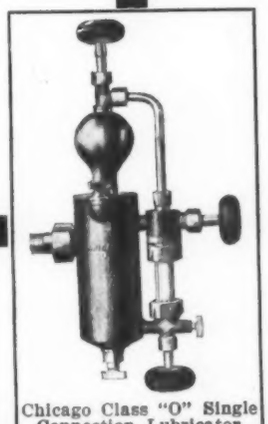


Chicago Double Connection Lubricator.



Chicago Ejector.



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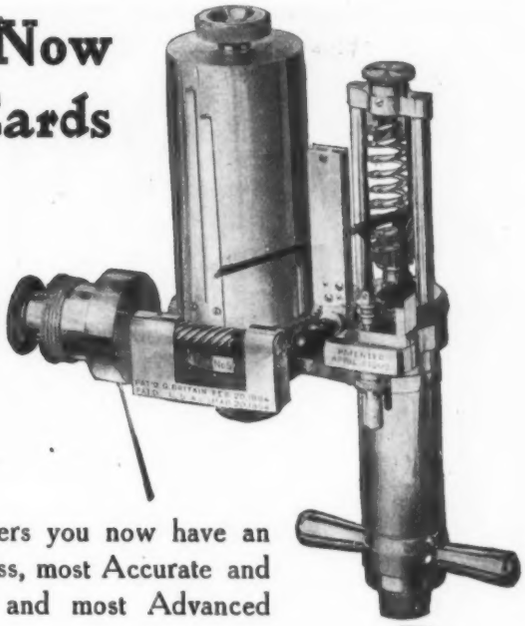

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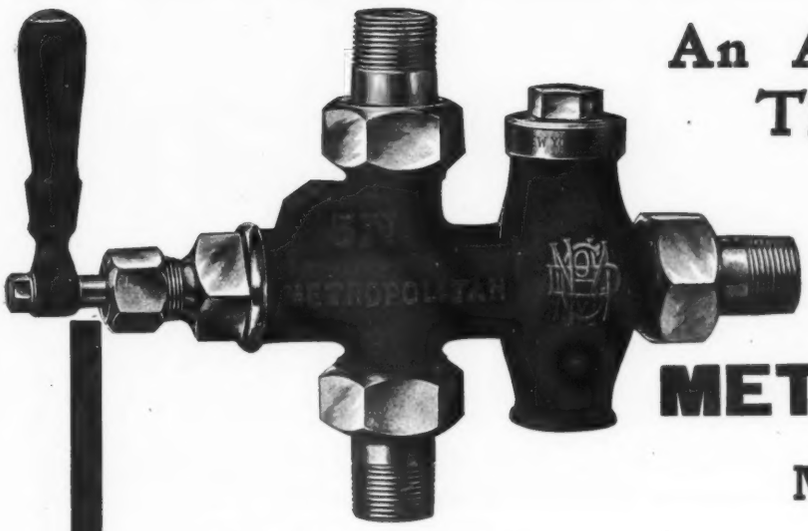

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METROPOLITAN

MODEL "N"

The ONLY injector which does NOT require a valve in steam and suction pipes for varying pressures.

Constructed of special metals and therefore the Injector which does not require continual repairs. Thoroughly tested under all conditions met in actual practice before being shipped.

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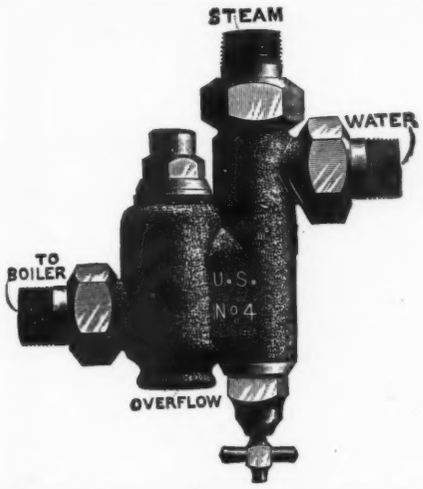

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They have just as firm a foothold abroad as at home. Only genuine merit has placed the "U. S. Automatic" in this position. The more particular you are about securing reliable boiler feeding—the better it pleases us—for we have the **only reliable boiler feeder.**

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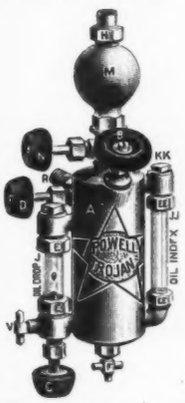

The Powell TROJAN sight up-feed Lubricator.

This body shell is cast in one piece—Powell construction—the arms can't get out of line and no joints to loosen or leak. This means positive feed, and perfect lubrication. Absolutely reliable under all conditions. Oil chamber is filled directly through filling cup B on all sizes.

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Powell's Steam Specialties are Standard. Ask your Jobber—he knows.
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No Waiting
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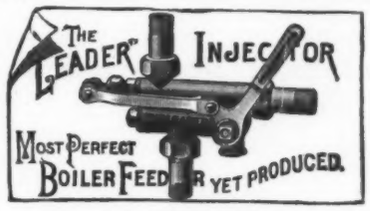

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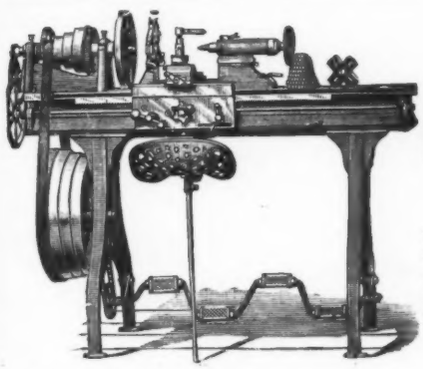

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Combination Metal Insertion Packing

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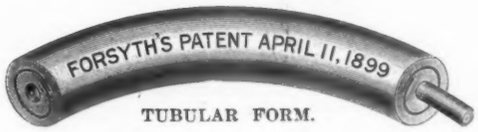

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The best of rubber packing with one or more plies of metal inseparably inserted.

The advantages of both metal and rubber, the disadvantages of neither.

More life, elasticity and durability than cloth or wire insertion packing.

The Tubular packing makes durable gaskets of any size or shape without waste.

Will satisfactorily withstand the heat of high pressure steam, as it is practically a metal packing with elastic surfaces.

A trial of the goods proves their worth, as hundreds of engineers can testify.

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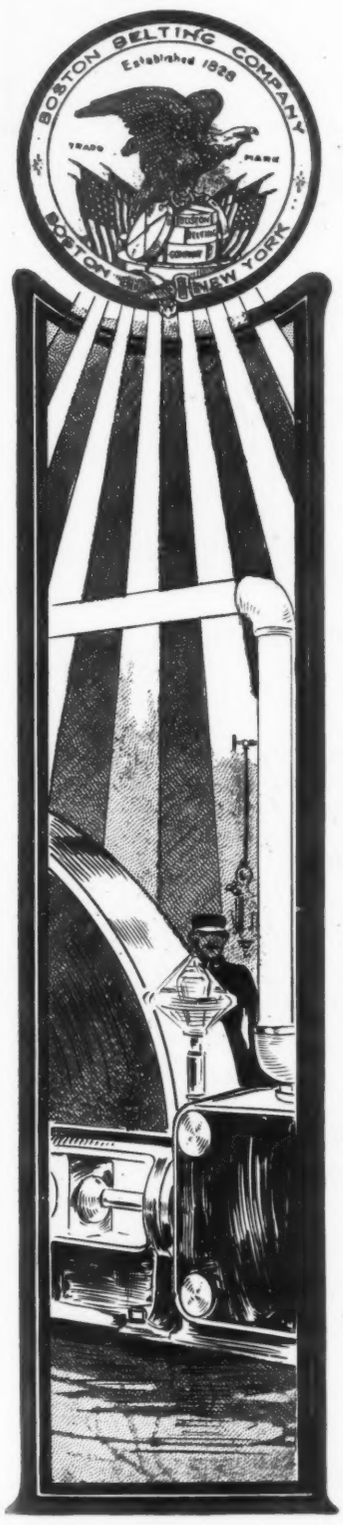

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Rubber belting, hose of all kinds, **packings** in great variety, **gaskets, valves, rubber mats and matting.**

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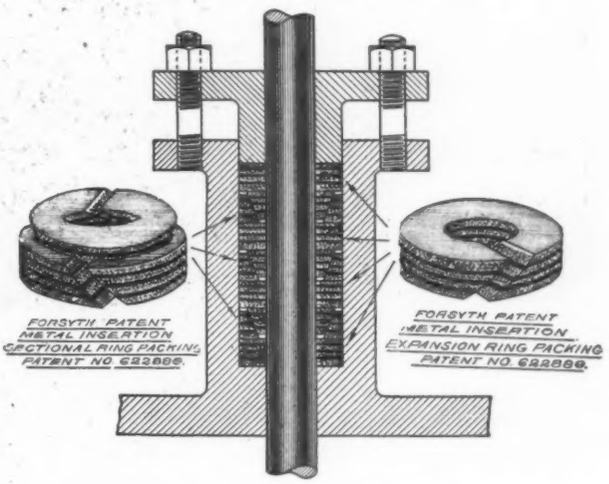

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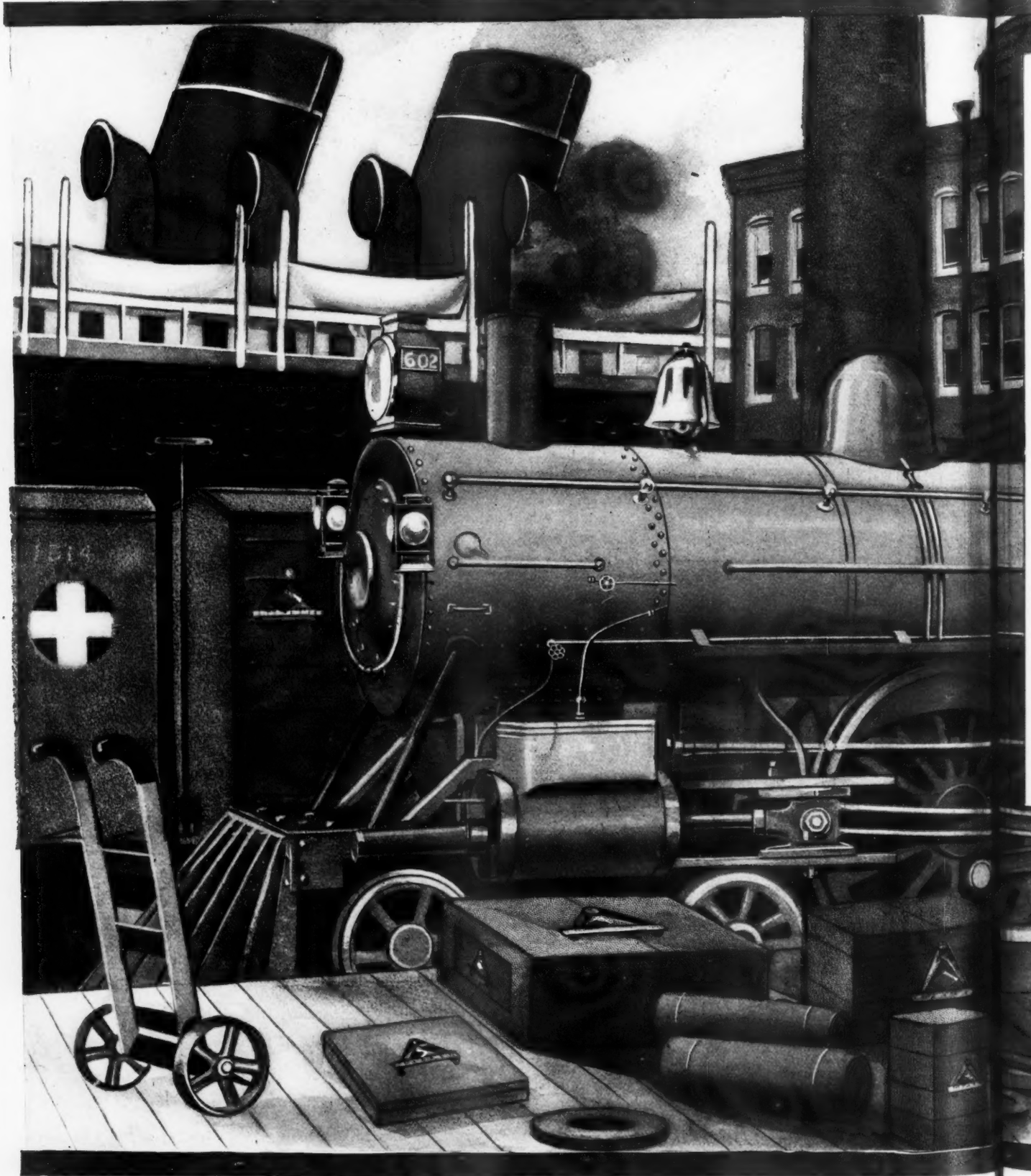

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A present of some little worth,
And yet you quite often neglect to attend
To the best friend you have on earth—

YOUR PLANT!

An order to-day will bring you the proper Packing or Supplies for your Engines and Pumps. They are too expensive for you to neglect. If you treat them *carelessly you must not expect them to work* well for you.

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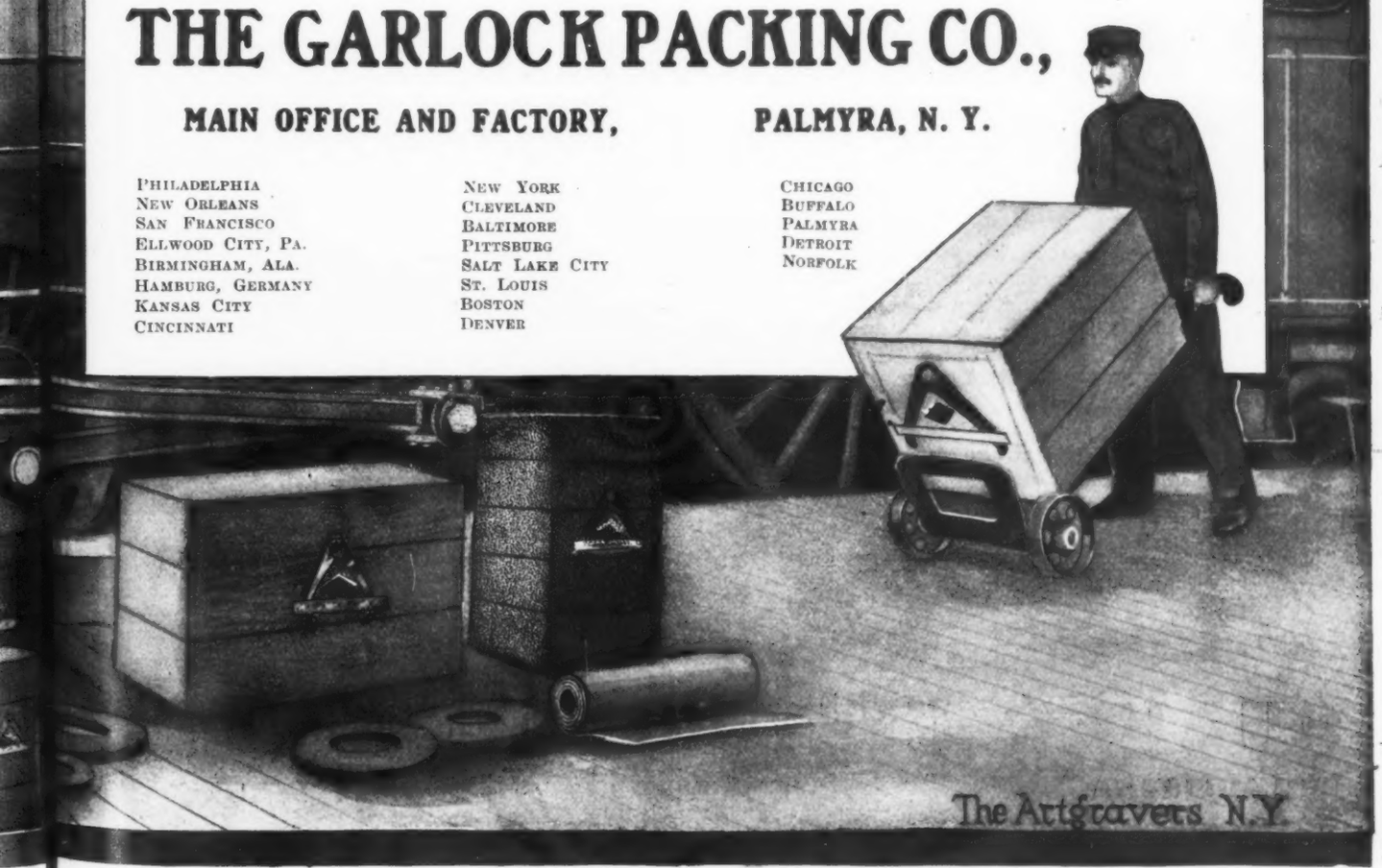
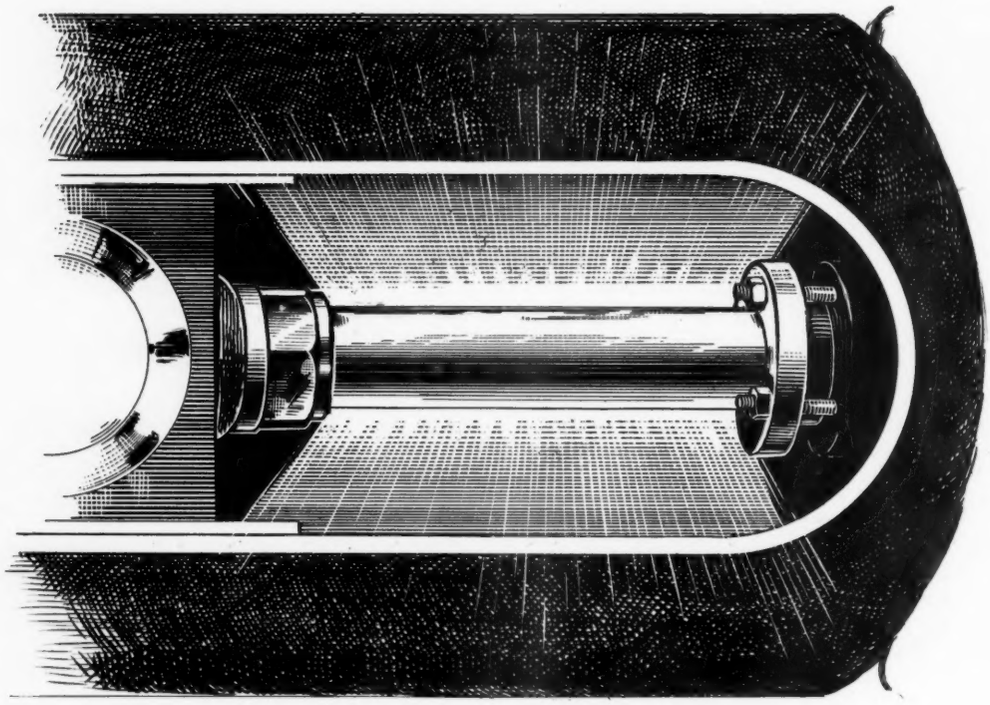


A Shiny Rod



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It keeps the rod bright, smooth and in perfect condition. It coats it with a lubricant that fills up the scratches, oils and preserves it without roughing. And it positively prevents the escapement of all steam without causing the least friction.

Here's why:

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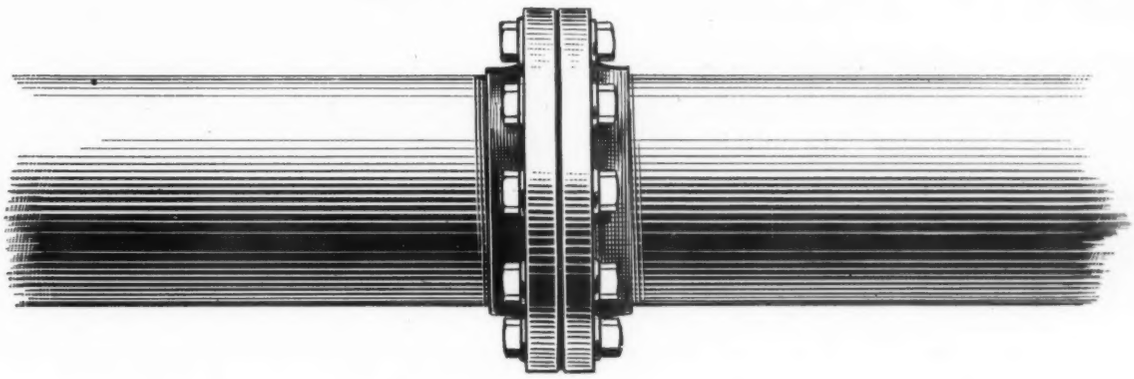
PHILADELPHIA **CHICAGO** **PITTSBURG**

A Tight Joint



Ebonite Sheet Packing Makes Good Where Other Packings Fail

Varying Expansion or Contraction of the Pipes Has No Effect Upon Its Efficiency

Consider what it really means to have a perfectly tight joint. Not a joint that will remain tight as long as existing conditions are favorable—but a joint that will be tight under ALL conditions, tests and strains.

EBONITE HIGH PRESSURE BLACK SHEET PACKING makes such a joint an actual reality. It's a different sort of packing from the rest. It won't get hard. It retains its flexibility, won't blow out, crumble, carbonize or rot.

Not another sheet packing possesses the same elasticity—the remarkable elasticity which causes it to *hold firmly* under expansion or contraction. Not another packing will wear as long, give half as good service or prove nearly so economical as EBONITE.

It will hold a vibrating joint absolutely tight. It will keep a tight grip on expenses. The plant that uses EBONITE is well protected against the expenditure of unnecessary dollars.

Don't lag behind in the race for profits. EBONITE will give you a big impetus, place you in the lead, and keep you there. Your dollars can't leak if your joints are packed with EBONITE. It's as good the day you take it out as the day you put it in. We'll send you our catalog.

Write for a Free Sample of P. P. P.—That's the First Step Toward Absolute Satisfaction

QUAKER CITY RUBBER CO.,

PHILADELPHIA CHICAGO PITTSBURG

The Bridge Of Economy
Is Supported By
DEAN Boiler Tube Cleaners

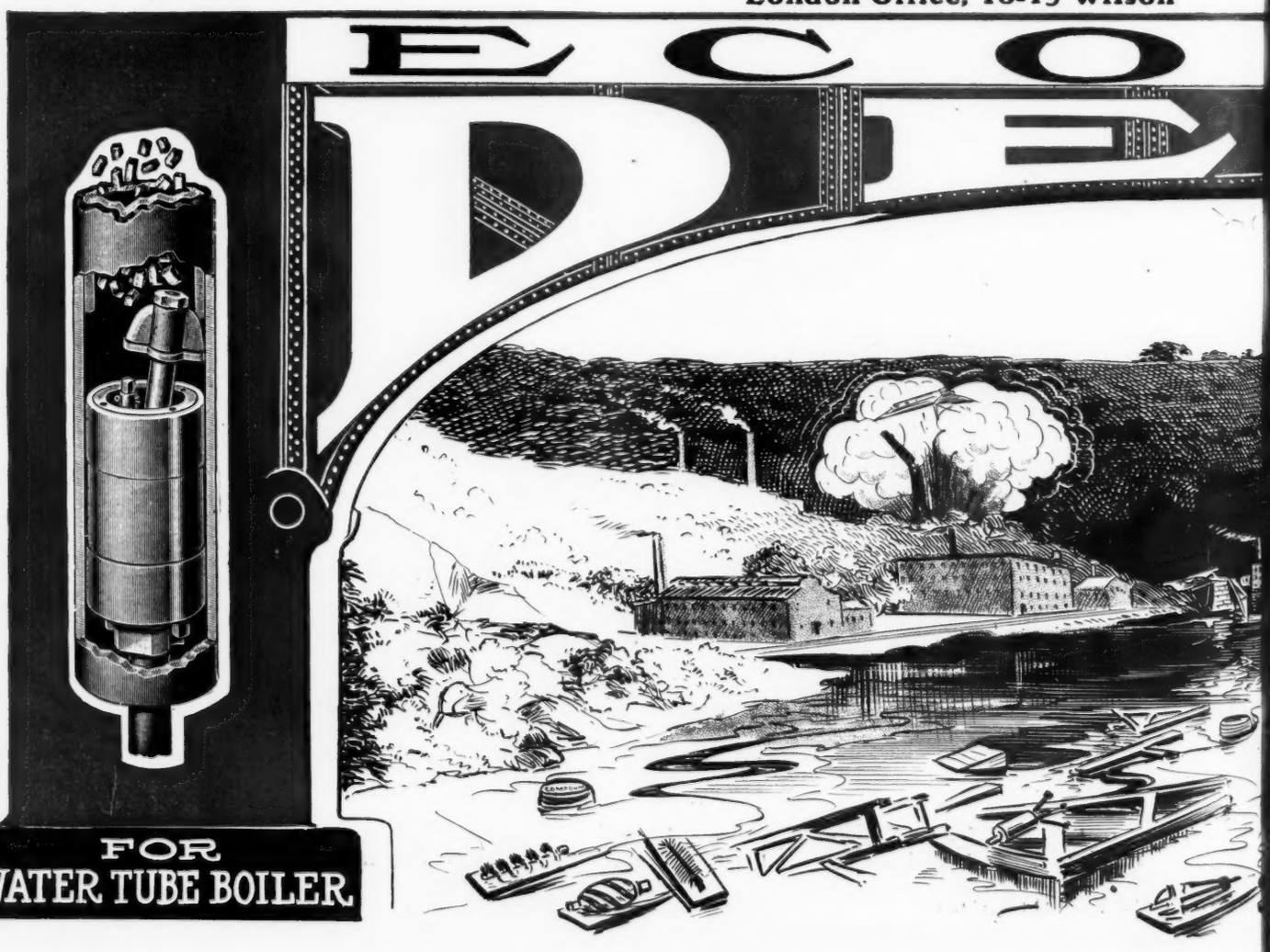
If Economy in the boiler plant appeals to you, don't try to ford the "River of Waste.". The "Bridge of Economy" is open to all steam users and the only toll is the price of a "Dean."

The "Dean" is *two* cleaners in *one*—adaptable to both water tube and return tubular boilers by simply changing the hammer head. It is durable, simple in construction, seldom out of repairs, saves 5 to 50% in fuel bills and prolongs the life of boilers 5 to 15 years.

Two clean boilers cost less for fuel than one dirty one—and where the "Dean" is used boilers must be clean. There's room for you on the "Bridge of Economy." Come on.

The Wm. B. Pierce Company,

London Office, 13-15 Wilson



How To Procure A DEAN On Trial---FREE! Ask For One---That's All!

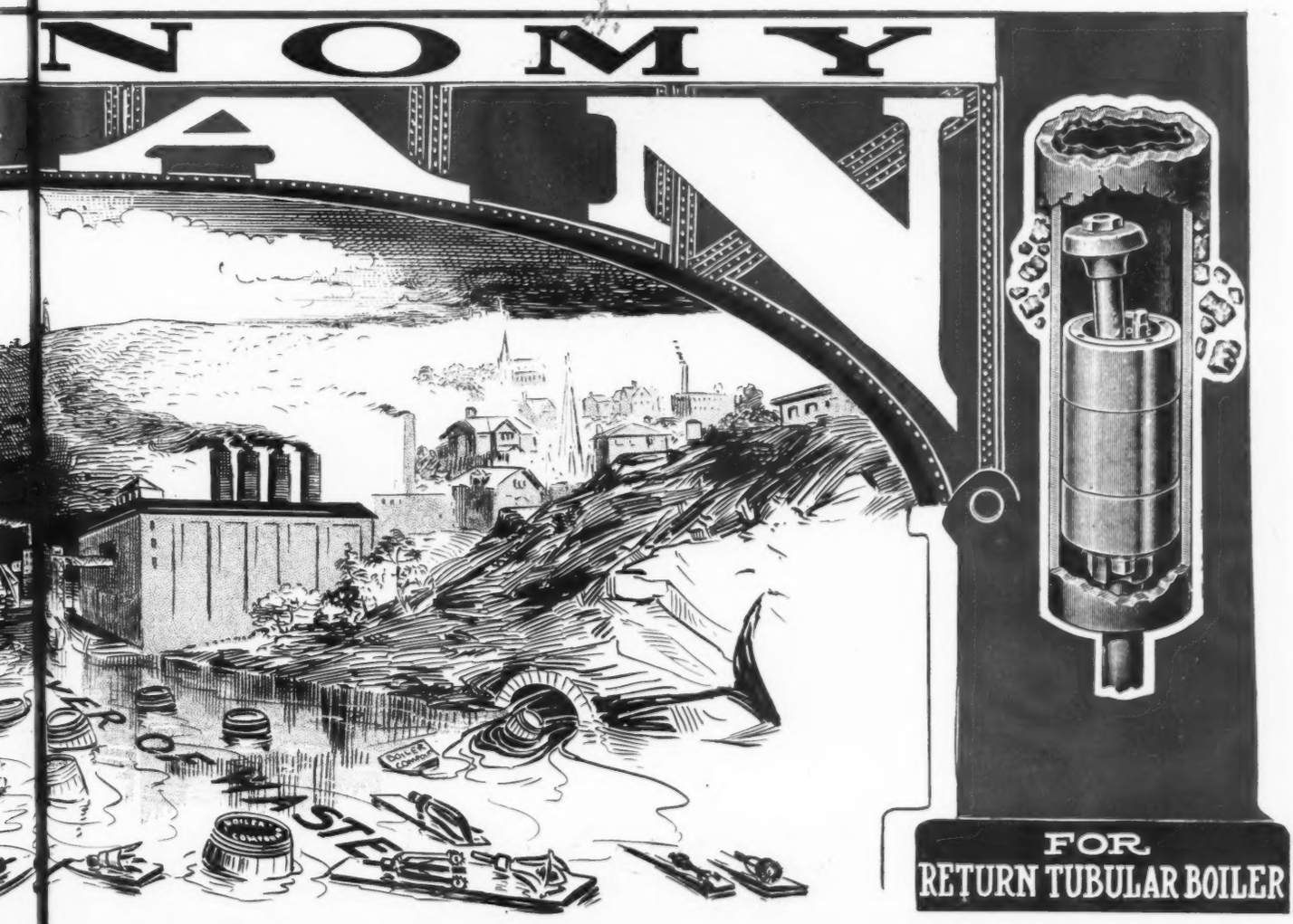
Give it the severest kind of a test on one boiler—then if it doesn't measure up to your requirements and our claims, fire it back at our expense.

Guarantee—Another thing, if, after you have used it six months, you find it hasn't paid for itself, send it back and we'll refund the purchase price.

Our latest booklet from the print shop, "*From Water To Steam*," will move your way as soon as we hear from you. Let it be today.

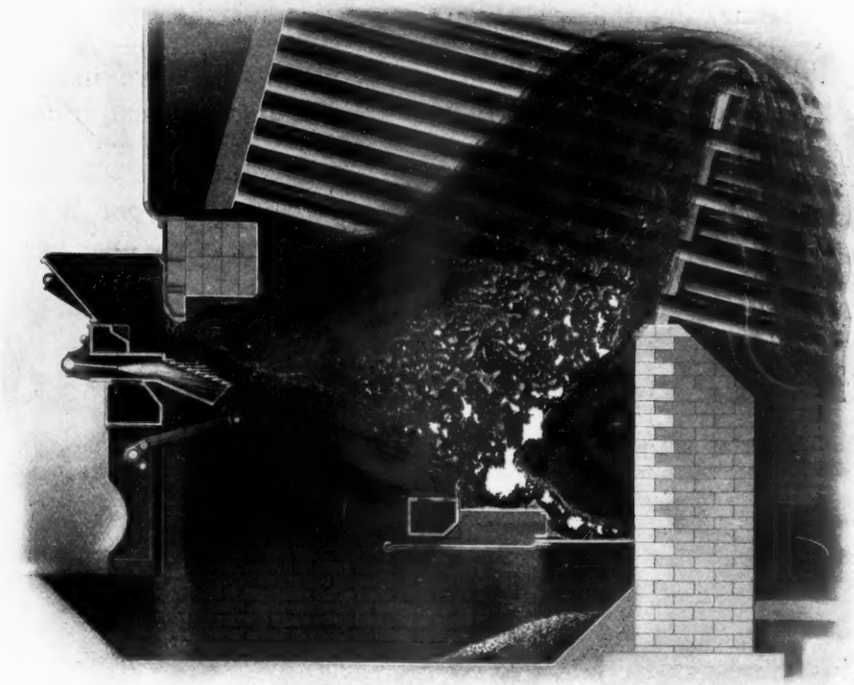
Jewett Building, Buffalo, N. Y.

Street, Finsbury, London, E. C.



TWO WAYS OF

The New Wilkinson Way



The Wilkinson Automatic Stoker And Smoke Preventer

accomplishes perfect combustion and makes valuable heat units of the thick black smoke that wastes your money when it belches up the stack.

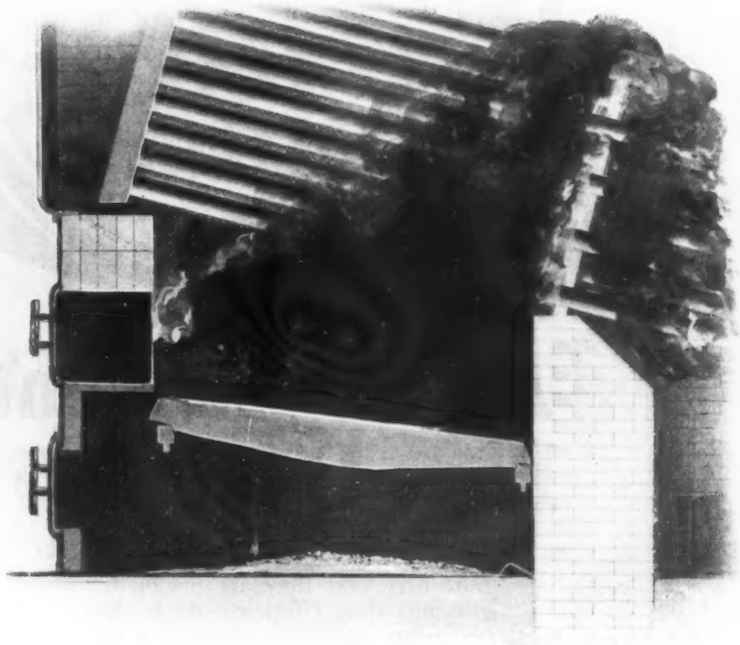
This apparatus, the result of 16 years' study and experience, is self-feeding, self-operating and self-cleaning. It does away with the necessity of opening doors and letting cold air rush onto the fire, it cuts out stoker's wages, it burns all kinds of coal, it never gets out of order and it makes an actual, tangible fuel saving of 5% to 15% over the hand-stoking method.

Therefore, it merits your investigation.

THE WILKINSON M'F'G CO.,

BURNING COAL

The Old Fashioned Way



The "Wilkinson" Burns Fuel Fast And Completely—No Smoldering

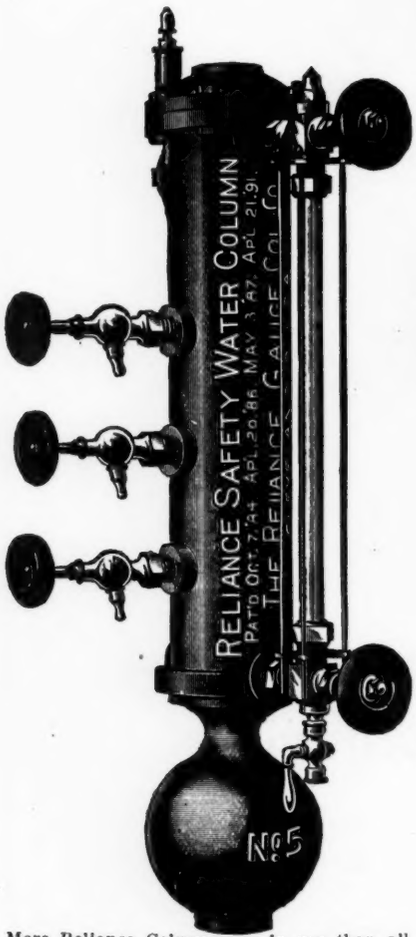
The *Wilkinson Stoker* feeds the coal into hopper and *mechanically forces* it through various zones of heat and combustion until, in the form of partly burned ashes, it rests on the ash table, whence, after burning out completely, it falls over onto the ash slide. Small steam jets, which are introduced into the ends of all hollow grate bars, preserve the bars and secure a gaseous combustion with all the accompanying benefits. The grate bars are guaranteed to stand severe action of fire, variable overloads and severe service. All parts are easy to remove and replace.

Any engineer will see the tremendous economy and gain to be gotten by the "WILKINSON," if he will send for a catalog and study it.

BRIDGEPORT, PENN., U. S. A.

55,000 In Daily Use

The Reliance Safety Water Column



More Reliance Columns are in use than all other Safety Water Columns Combined.

An Investment Which Pays Over 100% A Year

Reliance Safety Water Columns more than pay their cost the first year they are installed. After that, of course, the savings they effect are ALL clear profit. This is speaking from an economic standpoint entirely and does not include the absolute protection to life and property which goes with every Reliance Column purchased.

No matter from what standpoint you judge them—Reliance Columns win. They win on superior construction, on efficiency, on reliability, on simplicity, on their ability to add life to the boilers, and to rerder carelessness and negligence impossible.

Constant users proclaim them to be far above all others—read what one concern writes us—

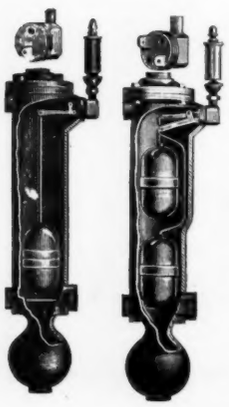
Champion Copper Company.
Painesdale, Mich., Oct. 28th, 1907.

The Reliance Gauge Column Co.,
Cleveland, Ohio.

Gentlemen:—

In reply to your letter of Oct. 18th, concerning Reliance Safety Water Columns, we several years ago adopted these as a standard on all our power plants and shall require our new power house boilers to be fitted with them.

Yours very truly,
Champion Copper Co.
W. A. Rankin,
Electrical Engineer.



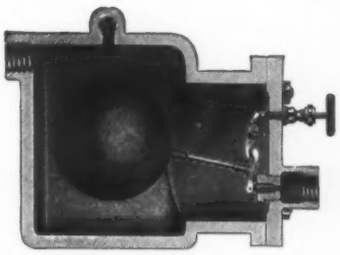
They are the best Column having a Sediment Chamber, the only columns whose operation is permanently successful and the only columns that can show such actual savings day after day, and year after year. Specify them for your boilers and see that no cheap imitations are palmed off on you instead. Look for the name "Reliance" cast on all columns purchased. Write for our booklet.

The Reliance

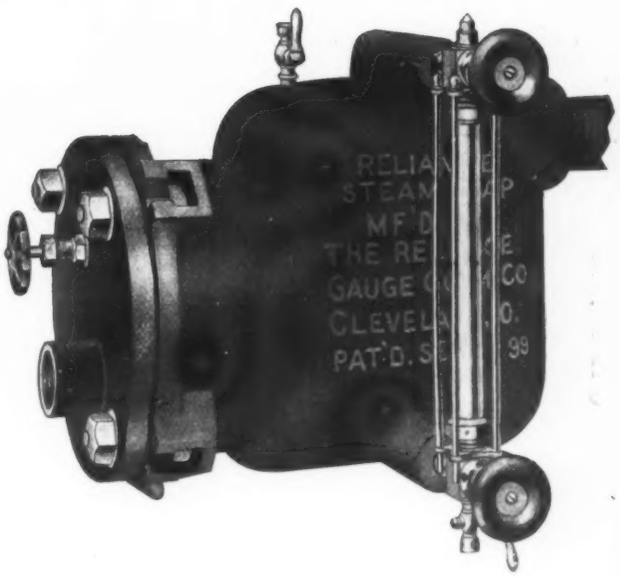
75 East Prospect St.,

The Reliance Steam Trap

Capacity, Efficiency and Durability



The Trap That Is Never "Off Duty" Is The Reliance



Reliance Steam Traps never have to "lay off" for repairs. Their name implies their character. They're wideawake and reliable always—belong in fact to the unfailing variety.

Note the simplicity. The entire internal mechanism can be instantly taken out by removing the cap from end of trap. This marked simplicity adds much to the high efficiency of these traps and helps render them the best on the market—superior construction and fine materials do the rest.

Read what users say of them:—

"We have four of your traps in constant operation and they are giving the best of results." The Victor Rubber Co., Springfield, Ohio.

"Have not had a minute's trouble with the Reliance Trap. Can recommend it highly." The Standard Hoop Co., West Bay City, Mich.

The best features of the more expensive traps are all found in Reliance Steam Traps. The valve construction is so sensitive that the slightest change governs it. If there's a little inflow of water, the valve opens but slightly, while if a large inflow enters the trap, the valve opens widely to meet the need.

Then consider "Reliance" Patent Floats. Many an otherwise good trap is spoiled by a poor, inferior float. "Reliance" Floats are the best that can be made—they're guaranteed not to collapse or fill with water.

We want to tell you the full story. We test and inspect each trap before shipment and guarantee satisfaction. Write for our circulars.

Gauge Column Co.,

Cleveland, Ohio.

Books For Engineers

Practical—every one of them. Helpful—all of them. Necessary—if you would keep posted to the minute on what's what in your profession. The BEST list of the BEST books published for Engineers

STEAM TURBINES. *By Lester G. French.* 340 pages, 6 x 9, cloth, fully illustrated, $3.00 postpaid. Steam turbines are coming—sure as rent day. You, Mr. Engineer, must understand them or they'll be looking for somebody to take your place. Here is a book for you—plain, practical, straightforward—but very thorough.

COMBUSTION AND SMOKELESS FURNACES. *By Joseph W. Hays.* 6 x 9, cloth, illustrated, $1.50. Whether you are building a new furnace or running an old one, whether you have smoke consumers or not—you need this practical everyday book. It will show you how much proper firing has to do with it—not from a theory but from a practical man's knowledge.

HANDBOOK ON ENGINEERING. (Steam and Electrical.) *By Henry C. Tulley.* Over 1000 pages, pocket size, leather with flap, $3.50 postpaid. The best all-round book there is. For full description see page 160 of this issue.

ENGINE ROOM CHEMISTRY. *By Prof. Augustus H. Gill,* of Massachusetts Institute of Technology. 200 pages. $1.00 postpaid. For full description see page 236 of this issue.

BOOKS ON GAS.

PRODUCER GAS AND GAS PRODUCERS. *By S. S. Wyer.* 296 pages, 6 x 9, cloth, illustrated, $4.00 postpaid.

One of the most important phases of Gas Power. You will in this work, get just what and all you need to know on Producers.

Now in preparation. Send us your orders.

GAS POWER. *By F. E. Junge.* 6⅛ x 9⅛, illustrated, $5.00 postpaid.

A full and complete study of Gas Engines, their design, construction and uses. This is based on Mr. Junge's admirable series in *Power*, but contains many new chapters. It is the most important work on this subject yet undertaken.

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THE POWER CATECHISM, $2.00.

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Power *The Engineering and Mining Journal* *American Machinist*

WILLIAMS

Safety Feed Water Regulator

Would You be Interested if we Proved Conclusively:

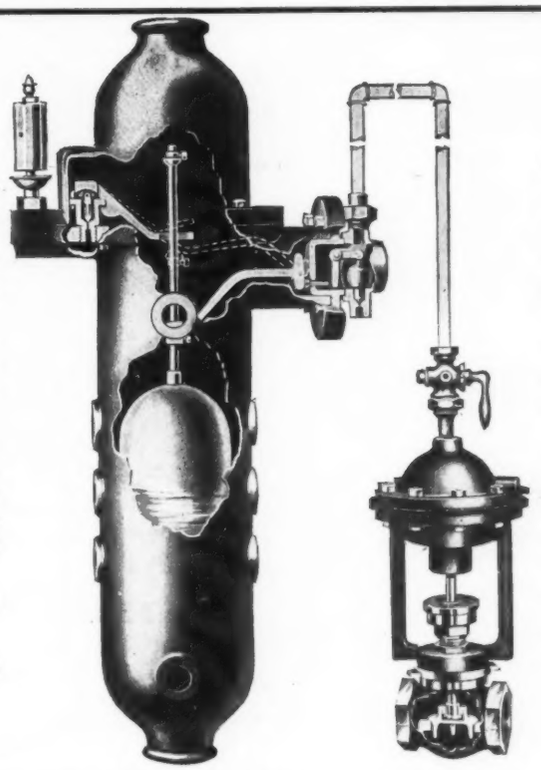
That we can save you from 3 to 15% of your fuel expenditures by the absolute maintenance of a dry steam supply, which, with the resultant increased boiler and engine efficiency effects a saving in labor, fuel and repairs?

That we can maintain a constant water level in your boilers irrespective of the character of your boiler room labor?

That in the largest plants in the country where our Regulators have been in use for years, they have paid for themselves at least twice annually in labor, fuel and repair economies effected?

That the device itself is "fool proof"?

If these results are obtained by present users, why not by you?



The enormous cost of repairs in present day boiler room maintenance is, in the main, due to inability to maintain a constant water level in the boilers. The boiler room labor is not, as a rule, the most dependable, making it advisable to adopt some method of safety controlling the admission of feed water.

The adoption of the Williams Automatic Safety Feed Water Regulator by the largest steam plant operators in the country is sufficient evidence that such a method has been found, and proven efficacious.

4,000,000 H. P. Boilers Equipped with

Williams Safety Feed Water Regulators

The Williams Steam Operated Trap

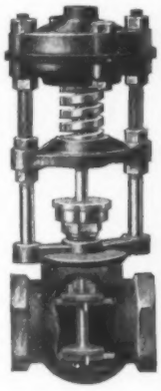
effectively drains and maintains a free and uninterrupted circulation throughout the piping system. The

discharge is instantaneous and positive. Its construction obviates all possibility of steam waste. There is absolutely no duty it will not perform, its capacity being practically unlimited.

The Williams Steam Pump Governor

Uniform pressure and sensitive pump control are essential features in modern steam pump operation.

The Williams Steam Pump Governor will control and maintain an unvarying pressure and at the same time obviate all possibility of the pump racing or accumulating excess pressure, which would be liable to burst the pipes. During the periods of no load, the position and sensitive action of the Williams Governor keeps the pump at rest. The slightest release of the water pressure is followed by the instant response of the Governor, which controls the gradual starting of the pump and maintains a steady pump stroke. The resulting constant discharge pressure gives a higher and more uniform feed water temperature.



This Governor will operate with a maximum variation of about two pounds.

Catalogs and Blueprints on Request.

THE WILLIAMS GAUGE CO., PITTSBURG, PA.

WEAR WELL LEATHER PACKINGS

Save Dollars For You

Your cost of maintenance can be materially reduced and the efficiency of your machinery greatly increased by the use of "WEAR WELL" Leather Packings.

They are made of the best grades of leather procurable, each grade adapted for best results under certain conditions, and before you buy we know what your conditions are.

We then MAKE the packings to your specifications, thus providing you with a packing that is perfect in fit and PERMANENT IN WEAR.

Made in all styles and sizes for Steam, Hydraulic and Pneumatic Machinery and wherever leather packings are required. Send for descriptive booklet and samples.

Detroit Leather Specialty Co., Inc.
175 Beecher Ave., Detroit, Mich.

ALL SIZES—ALL STYLES

FREE!

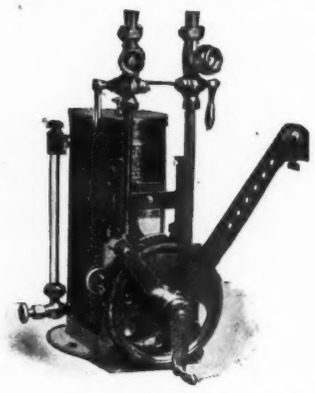
An attractive and interesting book, illustrated from photographs, containing information which should be in the hands of every engineer, superintendent or owner of a manufacturing plant. This book puts some facts in such a way that—but then, send for it and see. Please give firm name.

MAIN BELTING CO.
1221 Carpenter Street, Philadelphia, Pa.

IF you wish **just the right** amount of oil, in **just the right** place and at **just the right** intervals, use a Latest Improved

ROCHESTER

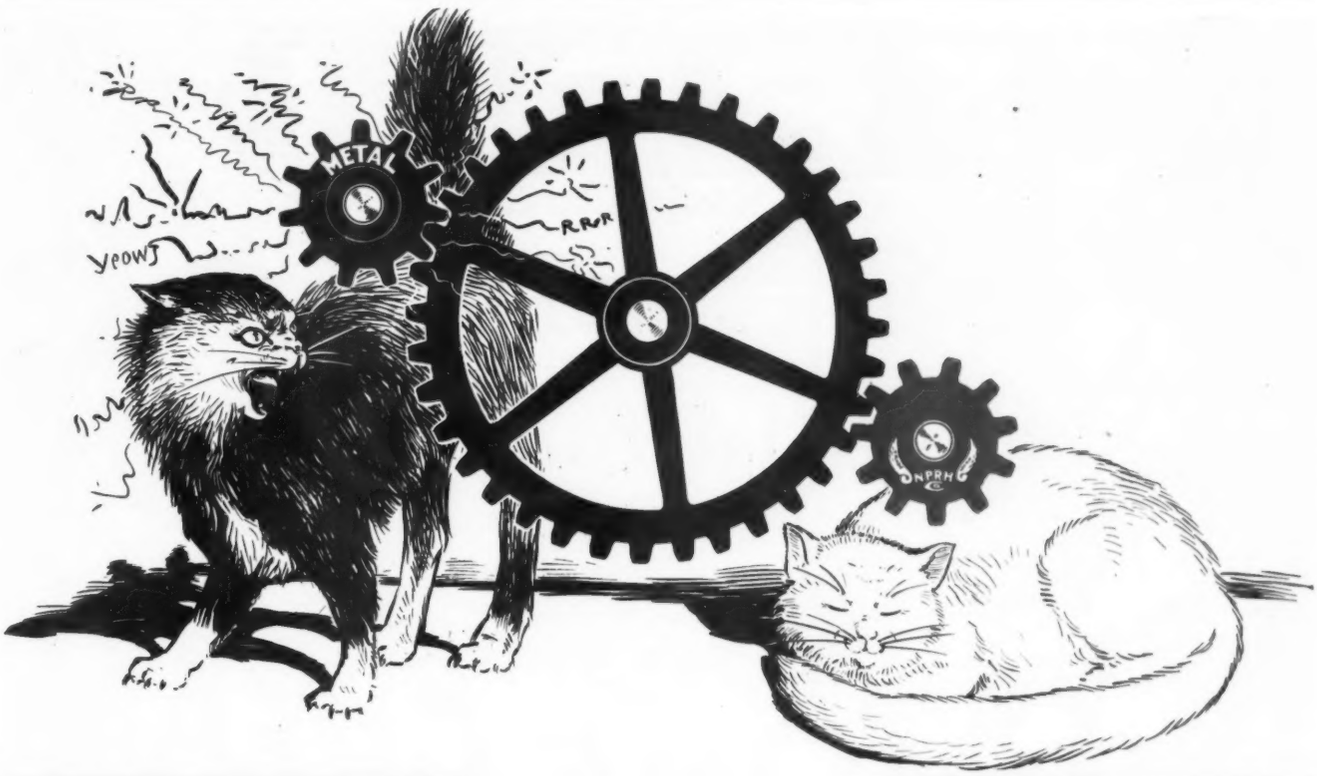
AUTOMATIC LUBRICATOR



Our 72 page catalog will be of interest to you, as it shows the "Rochester" attached to different styles of engines and pumps and also gives a list of some of the large plants where they are in use.

Send for a copy.

GREEN, TWEED & CO.,
109 Duane Street, NEW YORK.



Does Your Machinery Caterwaul Its Loudest Or Comfortably Purr?

Take two cats for example, the one caterwauling its loudest, the other comfortably purring, and you have a striking comparison between metal and New Process pinions when in operation.

There is no ring to rawhide, thus the teeth of a rawhide pinion striking upon the teeth of a metal gear wheel emit no noise.

But don't confuse New Process Rawhide with ordinary Rawhide. NEW PROCESS means exactly what the words imply.

As is steel to iron, so is New Process Rawhide to all other rawhide—and we can prove it.

So why suffer from a continual terrific racket when New Process Pinions will give perfect peace and quiet, save oil, save the gears they mesh with and create all-around satisfaction in general? Made in both Spurs and Bevels for all kinds of machinery. Write for catalog.

The New Process Raw Hide Co.,
Syracuse, N. Y.

Engineer's LUNCH BOX. **Large can of KEYSTONE GREASE.** **Fine heavy brass GREASE CUP.**

ALL FREE!

Sent Express Charges Prepaid.

To any engineer, superintendent or master mechanic who will take the trouble to fill in and send us this coupon.

All we ask is that you will give the grease a fair honest trial.

We guarantee that one pound of Keystone Grease will last longer and lubricate better than three to four pounds of any other grease or four to six gallons of any lubricating oil.

We want you to prove this to your own satisfaction, hence our offer.

Fill in and mail the coupon today. You'll never regret it.

Address

KEYSTONE LUBRICATING CO.,
DEPARTMENT B.
PHILADELPHIA, PA.

New England Office: 10 Oliver St., Boston. Southern Office: 610 Chartres St., New Orleans.

Tear Off Here:

Name .....

Address .....

.....

By Whom Employed.....

H. P. of Engine.....

On what bearing will sample be tested?.....

.....

Its Width.....

R.P.M. .....

Size of Tap for Cup.....

R.P.M. of Crank Pin.....

RHOADS LEATHER BELTING

ACTIVE

Is our code word for "Ship by express immediately," and while we don't invite hurry orders, for like everybody else we prefer ample time, still when you are really in a hurry, when you want good Belting and must have it at once, just add "Active" to your wire, and in most cases we will make shipment immediately. If not, we will wire you.

J. E. Rhoads & Sons,
Philadelphia, 12 N. Third St.
New York, 40 Fulton St.
Boston, Hamblet & Hayes Co., Selling Agents, 105-111 Summer Street.
Factory,
Wilmington, Delaware.

USE ONEIDA STEEL PULLEYS ONCE

Oneida Steel Pulleys

are made of steel. Are one-third the weight of cast-iron pulleys. Easy to erect and are absolute guarantees against dangerous accidents. Are made in sizes from 6" to 104" diameter, up to 40" face, 8" shaft. Large sizes a specialty.

AND YOU WILL ALWAYS USE THEM

On sale at the Fairbanks Company's branches. New York, Boston, Hartford, Philadelphia, Baltimore, New Orleans, Buffalo, Pittsburg, Syracuse, Albany and Bangor, also the Canadian-Fairbanks Co., Montreal, Toronto, Vancouver and Winnipeg. In fact, Oneida Steel Pulleys are on sale in all cities in the United States and in the principal cities of the world.

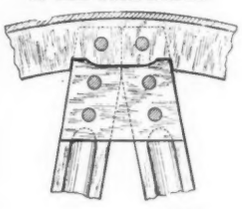
Oneida Steel Pulley Co., Oneida, N. Y.
105 So. Clinton St., Chicago.

12″ Diameter. 3″ Face.

36″ Diameter. 12″ Face.

Philips Pressed Steel Pulley

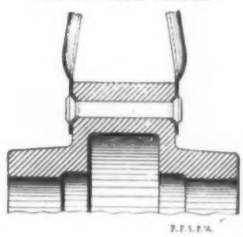
ENGAGEMENT OF RIM WITH SPIDER



P.P.S.P.W.

Recognized the world over as the only fundamentally new and best Pulley.

ENGAGEMENT OF HUB WITH SPIDER



P.P.S.P.W.

Larger construction with less weight.
Greater durability and safety.
Speed unthought of in the past.
Convenience, beauty of design, and a new field of possibilities.

The Philips Construction is ideal. The interlocking devices of spider at hub and rim make the pulley practically one piece.

Built throughout of high grade sheet steel, and weighing from ⅓ to ½ as much as a similar cast iron pulley.

ASK FOR BOOKLET

Philips Pressed Steel Pulley Works

301 to 335 Glenwood Avenue, Philadelphia, Pa.

The Perfect Hinge Joint or The Crude Hand Lacing.

WHICH?

The two illustrations clearly show the difference—The one is *strong, neat, durable and slip-proof*—the other insecure, dangerous and expensive.

The Peerless Belt Lacing Machine

will lace a 10-inch belt in five minutes at a cost of two cents and the lacing will last as long as the belt itself. It is always ready for use and its rapid work saves 10 to 25 minutes on each job, besides making a joint that has all the advantages of an endless glued belt at a small fraction of the cost.

The " PEERLESS" is by far the simplest and best tool ever devised for lacing belts and its wonderful saving of time, trouble, labor and money makes it invaluable wherever belts are used.

Send for descriptive Booklet.

PEERLESS BELT LACING MACHINE CO.,

Moore Cor. Swanson St., **PHILADELPHIA, PENNA.**

Plymouth Rope

Is As Strong Mechanically as

Plymouth Rock

Historically

"PLYMOUTH" MANILA ROPE is strong in every feature that counts for supremacy in Rope Drives.

In durability and tensile strength, quietness, absence of slip, small first cost, economy of maintenance, freedom from shut downs and electrical disturbances, PLYMOUTH ROPE stands SECOND to NONE. What is more, it has less stretch, is more flexible and can be spliced uniformly. Do you wonder at our statement, that PLYMOUTH ROPE is as strong in the Power Transmission field, as PLYMOUTH ROCK is in history.

If you would adopt the proper rope to meet YOUR conditions—let the Plymouth Cordage Company handle your proposition—every transmission problem is solved separately by men who KNOW—SPECIALISTS. This experience is yours—gratis. Our Book—"MANILA ROPE TRANSMISSION" sums up the strong points of PLYMOUTH ROPE—you ought to ask for it.

Plymouth Cordage Co.,

North Plymouth, Mass., U. S. A.

A Good Belt For Salt Water or Any Other Kind

OIL-STEAMPROOF "Aqua" WATERPROOF

The economy of Good Belting is well pointed out in this letter from Mr. Robt. Dumma, Chief Engineer of Onondaga Salt Springs, Syracuse, N. Y.

"Now about your Aqua belt. It was put on the 1st of May, 1906, and ran for 8 months, 24 hours each day, with only two stops of about twenty minutes, through the season, while with our six ply rubber belt we were shut down two or three times each week, which would most always happen in the night and keep us shut down from four to six hours. This belt being down in a dark pit, required two or three men to fix it, besides a wastage of thousands of gallons of salt water through the night. The condition of this Aqua belt when taken off at the end of the season was apparently as good as when put on, with the exception of the ends where it was laced. This belt ran a centrifugal pump, running 755 revolutions per minute, and raising 600 gallons of salt water to a tower 80 feet high. Taking all things into consideration, I think it the cheapest belt we have ever used."

Shultz Aqua is the only absolutely water-proof, steam-proof and acid-fume proof belt. It is made from heavy selected hides tanned by our secret process. This tanning makes leather impervious to water, steam, oil, acid-fumes and unaffected by extreme changes in temperature and humidity.

Where the belts are exposed to water or excessive dampness Aqua will give better service than any other belting. It will outwear any canvas, rubber or oak-tanned belt which has been stuffed or coated with water-proof compounds, and will transmit power with less loss from slippage.

For proof send for a sample. Ask for circular No. 4,' containing facts about "Aqua."

Our Sable Rawhide Belting is efficient and durable for drives where there is no moisture.

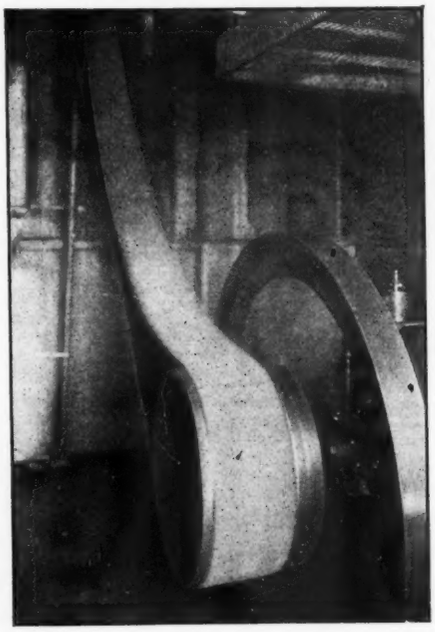
We send belts on 60 days' free trial.

SHULTZ BELTING CO.

NEW YORK BOSTON ST. LOUIS PHILADELPHIA

(Makers of "Sable" rawhide and "Aqua" belting, also belt dressing cement and lacings.)

17



Cling-Surface for Painted Cotton Belts.

You can use Cling-Surface for this class of belts just as you can for leather or any other class.

It will make and keep them pliable, prevent the cracking of the back which sometimes occurs, keep them waterproof and do them good.

Besides this, it will stop all slip, as Cling-Surface always does, and let you run every belt easy or slack and carry full loads.

This belt is in the Prince Handle Co. of Detroit. It is an 8" 3-ply painted belt, 14' centers from 20" iron to 14" wood pulleys, 12 to 14 H. P. gas engine, 220 R. P. M.

It has been treated with Cling-Surface for 2 years. It was very hard, dry and stiff and slipped badly.

Now it is pliable, clean and so slack the top just clears the bottom.

We guarantee results to you for cotton, also leather and ropes.

WRITE US.

CLING-SURFACE COMPANY

1049 Niagara St., Buffalo, N. Y., U. S. A.

New York Chicago Boston St. Louis Philadelphia Denver Etc

London Thomas & Bishop 119-125 Finsbury Pavement E C

LINK-BELT COMPANY

PHILADELPHIA CHICAGO INDIANAPOLIS

NEW YORK ST. LOUIS DENVER PITTSBURGH SEATTLE

Conveying and Power-Transmitting Machinery

Rope Drives In Dodge design you get the benefit of our 20 years' experience.

Estimates on request.

Dodge Manufacturing Co., Mishawaka, Ind.

THE GENUINE **GANDY**

What's The Use

of striving for economy in generating power if you lose it in transmission? GANDY STITCHED COTTON DUCK BELTS run straight and true; they grip the pulleys like a chain on a sprocket, and outwear any other several times over.

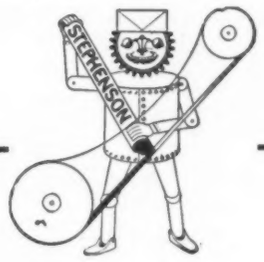
Best of all, the cost is low; only ⅓ that of leather and less than ⅔ that of rubber.

Send for our booklet—

"Experiences with Gandy"—it's good reading for belt buyers.

MAURICE GANDY
FOUNDER OF THE GENUINE RED STITCHED COTTON DUCK BELTING

THE GANDY BELTING CO.
BALTIMORE MD.



WHAT KIND and HOW?

—all in the picture.

And the picture is on each pound stick—SEE to it.

RED Label for Leather Belts; GREEN Label for Rubber or Canvas.

OF DEALERS EVERYWHERE, OR

STEPHENSON MFG. CO.,

E. A. KELLOGG, Vice-President.

ALBANY, N. Y.

Patented.

New Design American Pulley

The demand for this new "American" made in large sizes has increased to such an extent as to necessitate carrying the goods in stock in more than 100 cities in the United States and in the principal markets of Europe.

The Standard "American" was the first steel Pulley made and is still the first in all respects.

Light, Strong and True Running.

Fully Guaranteed.

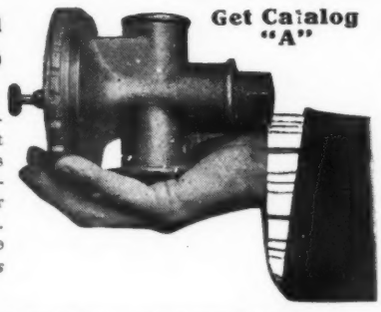
(TRADE MARK)

The American Pulley Co., **29th and Bristol Sts., PHILADELPHIA, PA.**

The Dunham Steam Trap

is one that you can trust It is free from all attachments that would detract in the slightest from its dependability. Has a motive force *ten times* greater than any float or bucket. How about sending one on *30 days' trial—Charges on us* if it "falls down"?

Get Catalog "A"



C. A. DUNHAM COMPANY,

Marshalltown, Iowa.

CLEVELAND. PHILADELPHIA. CHICAGO. TORONTO

Nason Steam Traps

"SIDELUG" TRAP
(Patented)

THE STANDARD FOR SIXTY YEARS!

Adapted for all conditions requiring the removal of condensation without loss of steam.

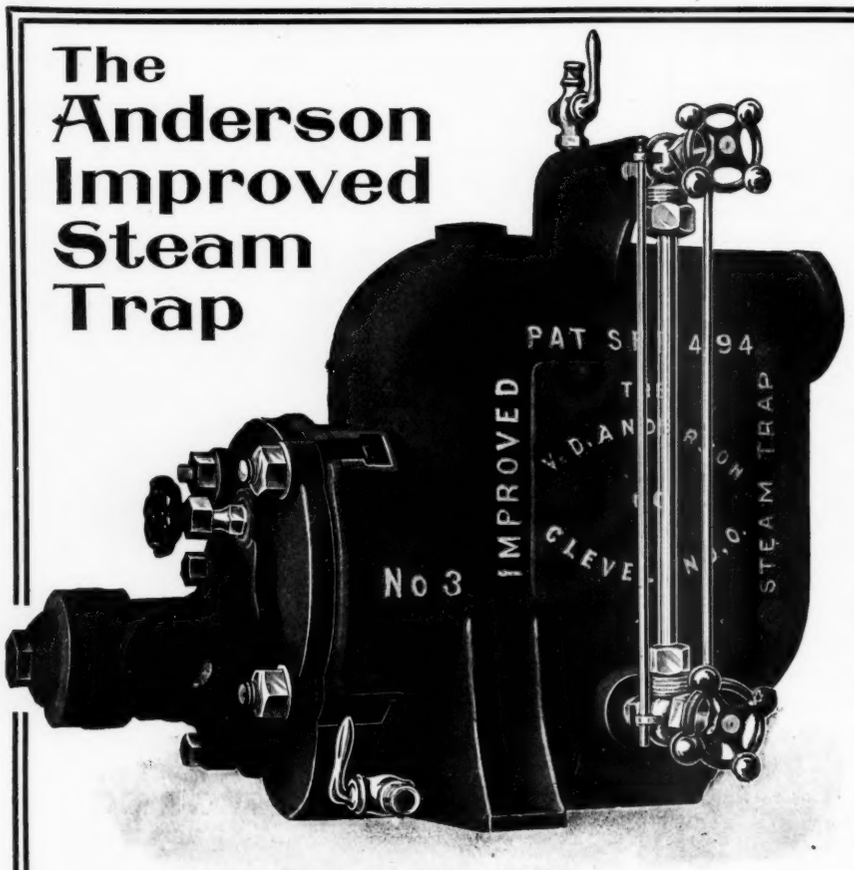
SPECIFY:

"CLASS B"—For pressures under 20 lbs.
"CLASS C"—For pressures between 20 and 70 lbs.
"SIDELUG"—For pressures higher than 40 to 150 lbs.

Send for Catalog

NASON MFG. CO., NEW YORK.

The Anderson Improved Steam Trap



Discharges The Water Holds The Steam Perfectly

It is all that its name implies—a trap for steam from which steam **never** escapes and water of condensation **invariably does.**

The body is constructed of close grained iron, with a valve which can be removed without disconnecting trap from pipes.

The valve and valve seat, of phosphor bronze, are simple in construction and easy of access.

The Anderson will deliver exhaust water against any back pressure five pounds less than the steam pressure at the trap.

THE V. D. Anderson Co.,
1935 West 96th Street,
Cleveland, Ohio.

LEST YOU FORGET!

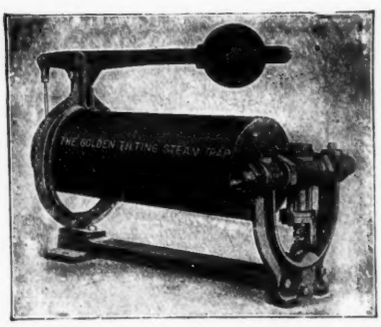
THE GEIPEL STEAM TRAP?

Works equally well with high or low pressure steam, and in any position.

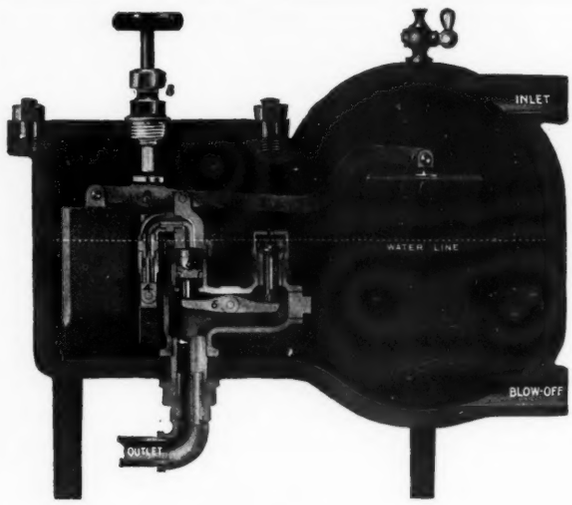
JOHN PLATT & CO.,
97 Cedar Street, NEW YORK.

ALL WORKING PARTS OUTSIDE

Thus you can tell simply by looking at the Golden Tilting Steam Trap that "things are going along all right." There are no hidden floats, valves or buckets inside the trap to cause trouble. Instead there is simplicy and high efficiency. We guarantee these traps.



Golden-Anderson Valve Specialty Company,
1017 Fulton Bldg., Pittsburg, Pa.

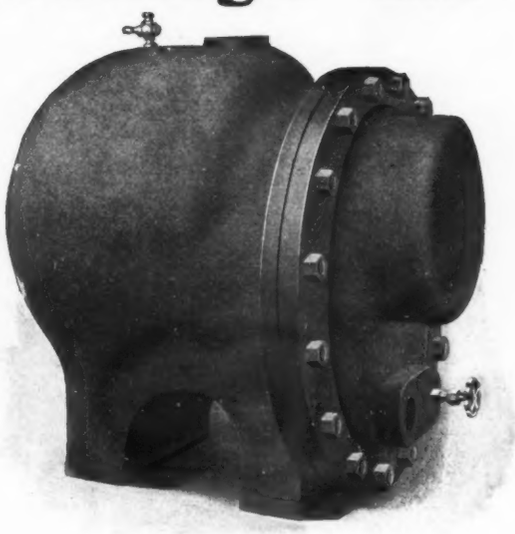


IF you are going to install new traps, or are dissatisfied with your present equipment, look up the STERLING STEAM TRAPS. The resulting economy in *time, labor* and *fuel* will make the adoption of one or more of these traps *worth while.*

Printed Matter Mailed On Request.

THE TEMPLETON MFG. CO.,
22 Randolph Street :: :: BOSTON, MASS.
N. Y. Office, 725 Broadway.

"Discharges" Like a Gun When the Float Pulls the "Trigger."



Unlike other traps, the **WYOMING** does not depend on the buoyancy of its float to lift the discharge valve.

The *float*, at its highest and lowest, simply releases a latch (like pulling the trigger of a gun). This latch *opens* or *closes* the *discharge valve.*

Thus the VALVE is always entirely *open* or entirely *closed.*

We *guarantee* these traps to be made in the best way, of the best materials, and to give perfect satisfaction. **Sent on 30 days' free trial.**

Let us tell you about the Wyoming Steam Trap.

THE WYOMING STEAM TRAP

W. H. NICHOLSON & COMPANY, Wilkes-Barre, Penna., U. S. A.

FLINN DIFFERENTIAL STEAM TRAPS

Save their Cost by Increasing Engine Efficiency.

THE EDWARD P. ALLIS COMPANY, Milwaukee, Wis.

[AFTER SELLING OVER 500 FLINN TRAPS]

Replying to yours of the 17th inst., we would say that we have used the FLINN DIFFERENTIAL STEAM TRAP for a number of years, practically since its first introduction, and have found it the most general satisfactory trap we have ever used.

Yours truly,

(Signed) THE EDWARD P. ALLIS COMPANY,

By Irving H. Reynolds.

DESCRIPTIVE CIRCULAR ON REQUEST.

RICHARD J. FLINN, West Roxbury Station, Boston, Mass.

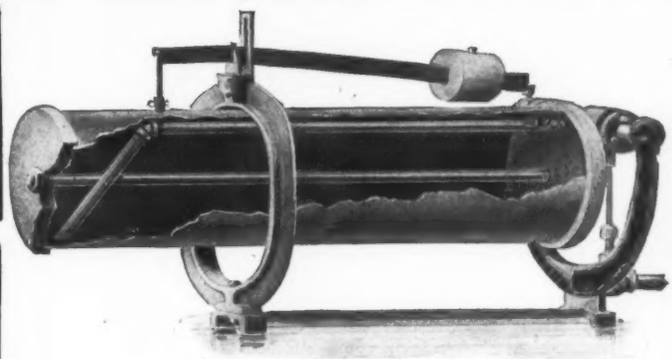
Send for
Nugent's Valuable Treatise on
HOW TO OIL AN ENGINE
and large catalog of new and
Up-to-date Oiling Devices for Hot Members

WM. W. NUGENT & CO.,
18-30 W. Randolph St., Chicago, U S.A.
Rimington Bros., Carlisle, England, Agents.

80 PAGES ON LUBRICATION

New, fresh, helpful information that you can use in your daily work. Lubrication of almost every class of machinery is treated of in this Tenth Edition of "Graphite as a Lubricant"—the value and dignity of a textbook without technical dryness. Write for free copy 94-C.

Joseph Dixon Crucible Company
JERSEY CITY NEW JERSEY



True Talk On Trap Troubles.

You won't get caught on a steam trap if you buy a

RYAN

It is not a cheap trap but it is inexpensive, simple, durable and guaranteed to cure trap troubles once and for all.

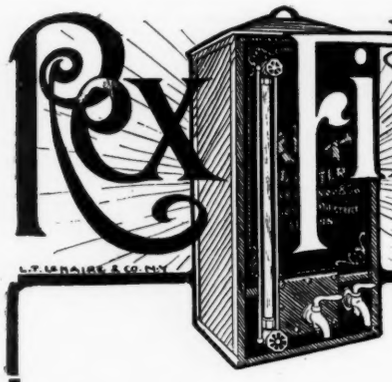
It is also convertable into a return trap by simply changing the valve and one inner tube.

Booklet "B"?

E. J. RYAN,

115 N. WALNUT ST., DANVILLE, ILLINOIS.

Rex Filters



There's Money Enough In The REX and ACME FILTERS To Pay For Them Many Times Over

We will send you a filter on 30 days' trial. If you do not find the money in that time—return the filter at our expense.

THE REX

(multiple system) is especially adapted to large plants, and occupies but very little space whether you use one or many.

Standard Rex filter is 18x18x36 and filters 150 gallons every 24 hours. Made in five sizes, 50, 100, 150, 300, and 500 gallons capacity. Write for folder.

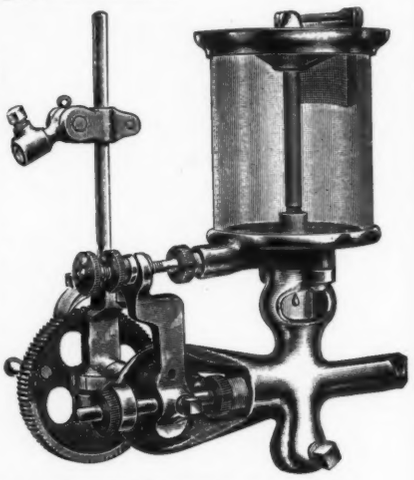
The Acme like the Rex is unsurpassed in excellence of construction and filtering capacity, uses animal bone black instead of cotton waste as a filtering material and can be depended on for thorough efficiency and long life.

WILL YOU TRY ONE 30 DAYS?

Walter L. Flower
Steam Specialty Company,
311 So. 8th Street, St. Louis, Mo.

Here's a Lubrication Tip.

Just a reminder that the *Manzel way* of lubrication is the *most profitable* way. It has all other methods beaten to a pulp. It puts oil where wanted—when wanted—in the right quantities to produce the best results.



Our money backs up our claims. Try this oiling device for 30 days—if it "falls down we pay for the *return trip.*"

Ask for our booklet, "POSITIVE LUBRICATION."

MANZEL BROTHERS CO.,
326 Babcock St., Buffalo, N. Y.

Why Do You Keep Putting It Off?

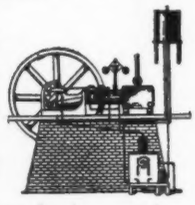
WHY DON'T YOU INSTALL A

WHITE STAR CONTINUOUS OILING SYSTEM

IN YOUR ENGINE ROOM?

¶ You positively cannot afford to keep on in the old rut. The longer you delay, the more money you waste—the more trouble and work you have.

¶ With the White Star System, the oil is fed continuously in a steady stream onto all the bearings, passes to the White Star Filter for thorough purification by removal of all foreign matter, and is pumped back to the oil reservoir for use again. Thus the oil is worked over and over until actually worn out.



¶ You feed the oil in a copious flood, yet without waste. Not a drop is lost.

¶ The advantages of this modern mechanical method in engine lubrication are fully exploited in booklet "D-2" which we have just issued for distribution to all who are interested.

Pittsburgh Gage & Supply Co.,
PITTSBURGH, PA.

1868—1908

40 YEARS IN UNIVERSAL USE—IN ALL PARTS OF THE WORLD

AND THERE IS ONLY ONE

ALBANY GREASE

Special Offer

A can of Albany Grease, with an Albany Grease Cup, free of charge or expense for testing. The only information necessary to send is pipe connection in the bearing, **depth of oil hole from top of cap to journal,** and give particular part of machinery on which the same is to be tested, Always send name of firm.

Result

Terrazas, Chih., Aug. 8, 1907
Adam Cook's Sons
New York, N. Y.

Gentlemen:

Your favor of July 31st at hand and contents noted. In reply to same will say that we are consumers of Albany Grease, we receive our supply from Chihuahua supply houses and know the value of Albany Grease. We have found the same to be a pure lubricant, and therefore will continue to use the same wherever we can

Thanking you for the information, we beg to remain.

Yours truly,
RIO TINTO MINES & SMELTING CO.
H. L. Schneider, Supt.

"OEZRIC"

Nothing Easier I See

than to ask for the genuine ALBANY GREASE

Trademark on the package guarantees the genuine.

For every GENUINE article there are many IMITATIONS

The IMITATOR has no REPUTATION to sustain.

When you ask for ALBANY GREASE SEE that you get it.

REFUSE IMITATIONS

It is the Best, Cheapest, Cleanest and Safest Lubricant

ADAPTED FOR ALL KINDS OF MACHINERY

Can be used in any style Grease Cup, WILL NOT GUM, FREEZE OR LEAVE A SEDIMENT, is uniform in quality and FREE FROM IMPURITIES.

Does Not Drip, Splash or Waste Away.

Manufactured only By

ADAM COOK'S SONS,

313 West Street, NEW YORK CITY.

DO NOT

Renew Your Contract

until you have tried

Anti-Corrosive Cylinder Oil

which will run your engine at less cost than any other cylinder oil.

It costs more per gallon but less per annum.

We will send you a barrel for 90 days' trial, and if after the trial you consider our price high, send us (for that one barrel) the amount you think right and we will send you a receipt in full.

ANTI-CORROSIVE CYLINDER OIL MANUFACTURED ONLY BY E. H. KELLOGG & CO. 243 & 245 SOUTH ST. NEW YORK, U.S.A.

E. H. Kellogg & Co.,

243 South Street,

New York.

8 B Rumford Court, Liverpool, England.

HARRIS

TRADE MARK REGISTERED

OILS

If You Use Oil Use A Good Oil

It cannot be of too good quality. Do not imagine that oil is just oil, and one brand as good as another. No greater mistake could be made.

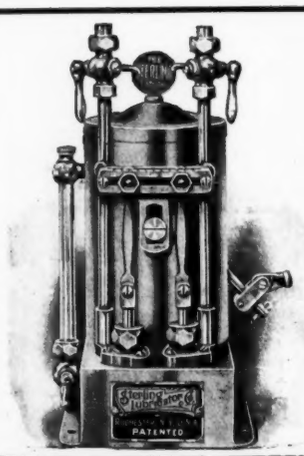
HARRIS OILS

are not only the BEST and will keep your engine in perfect condition, but are the most economical because of their great lubricating power and durability in use.

A. W. HARRIS OIL CO.

323 So. Water St.

Providence, R. I.



You are the best Judge of your own needs

STERLING FORCE FEED LUBRICATOR

ECONOMICAL
NOISELESS
RELIABLE
POSITIVE

Have one on thirty days' trial Free?

Sterling Lubricator Co.,
3 Frank St., Rochester, N. Y.

With Your Eyes Shut

you can do all the watching necessary for the

Swain Lubricator

It will furnish exactly the right amount of lubricant, feeding by gravity and working only while the machinery is in operation

Ask for Particulars.

SWAIN LUBRICATOR CO.,
250 Lake Street, Chicago, Ill.

SALES AGENTS

SIGHT FEED OIL PUMP CO.

SALES AGENTS

NEW YORK, N. Y.
Wm. Martin, 90 West Street.

BOSTON, MASS.
H. E. Rundlett, 141 Milk St.

PITTSBURG, PA.
Laughlin, Green & Co., 426 4th Avenue.

SCRANTON, PA.
Scranton Supply & Machinery Co., 131 Wyoming Ave.

ALLENTOWN, PA.
The William H. Taylor Co.

OMAHA, NEBRASKA.
The Sunderland Roofing and Supply Co., 1006 Douglas St.

Model "G" Eighteen-Feed, Automatic Oil Pump—3 Kinds Of Oil.

HAZLETON, PA.
Hazleton Machinery & Supply Company.

CHICAGO, ILL.
Alex. Hodgart, 1207 Fisher Building.

BIRMINGHAM, ALA.
James J. O'Rourke, 521 Brown-Marx Building.

SAN FRANCISCO, CAL.
Phoenix Tool and Valve Co., 131 Beale St.

CINCINNATI, OHIO.
T. B. Clark, 504 W. Seventh St.

MONTREAL, CANADA.
Homer Taylor, Temple Bldg.

MILWAUKEE, WIS., U. S. A.

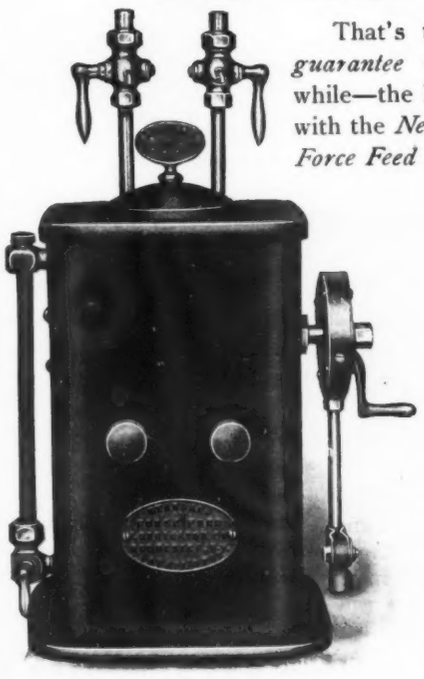
TRADE MARK REGISTERED IN
NON-FLUID OILS
UNITED STATES PATENT OFFICE

GREASE
feeds as it is melted by
frictional heat.
NON-FLUID OIL
lubricates like an *oil* without
frictional heat (like grease)
and without dripping
and spattering
(like oil).

Send us size and speed of your journal and your *Business Address* and we will send you, express paid, a sample can of Non-Fluid Oil suited to your needs.
Do you want to look over a copy of "The White Boa ?"
A little sketch which is nine-tenths amusing and one-tenth advertising.

New York & New Jersey Lubricant Company
Dept A, 14-16 Church St., New York.

A Guarantee Without Time Limit.

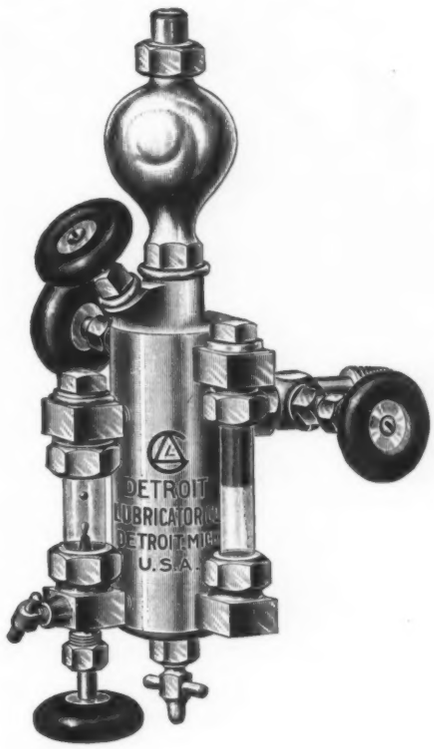


That's the kind of a *guarantee* that's worth while—the kind that goes with the *New "Standard" Force Feed Lubricator.*

In the *New "Standard"* you secure a lubricator that has every good feature found in others, besides, several features solely *"Standard."*

Ask for the *Booklet* which pictures and describes.

Standard Force Feed Lubricator Co.,
38-40-42 North Water St., Rochester, N. Y.



IT'S THE CORRECT HANDling of first-class materials that accounts for the pronounced success of DETROIT LUBRICATORS. Every part is made with exacting care; as a result the finished lubricator is as near perfect as a lubricator ever gets. More than this, every part is inspected after each operation, and the finished product submitted to rigid tests and inspection before shipment. This explains why over 850,000 DETROIT LUBRICATORS are rendering satisfactory service on two hemispheres.

Ask about our
20 Days' Free Trial.

Detroit Lubricator Co.,

Detroit, Michigan.

The Carnival of the

SQUEAK DEVILS

Use our **No. 205 Lubricating Graphite** and relieve friction, save power and stop the squeaks. It is a perfectly pure, soft, adhesive graphite powder, *not flake*, but air-floated and gritless. It smoothes out some mighty bad kinks, because it "stays put" and makes smooth, mirror-like, almost

Frictionless Surfaces

Its use is rapidly increasing among locomotive and stationary engineers, autoists, mill-men and machinery users.

A sample can, sent free on request, will give you new ideas about better lubrication. Please name your dealer. Ask for Booklet L 1.

THE UNITED STATES GRAPHITE CO.
Saginaw, Mich., U. S. A.

Traveling Cranes with Chain Blocks

afford the most approved engine-room lifting arrangement. The crane should span the whole floor operating on runways on the walls. Where power units are large, chain blocks for handling both light and heavy loads can operate on the same crane, facilitating work. The Y. & T. Electric Hoist is also available for this service.

Catalogs Free.

YALE & TOWNE MFG. CO.
9 Murray Street, NEW YORK.

CRANES

For Power Stations and Shops. Coal Storage Hoisting and Conveying Plants.

Electric and Hand. Catalog Free. Electric Traveling Trolley Hoists and Tracks.

New York:—120 Liberty St.
Philadelphia:—Land Title Bldg.
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NORTHERN ENGINEERING WORKS,
5 Chene St., Detroit, Mich., U.S.A.

MACHINE DESIGN By CHARLES L. GRIFFIN, S. B
Mechanical Engineer, Semet-Solvay Co., Syracuse, N. Y. Member American Society of Mechanical Engineers.

Bound in Cloth—184 pages—each nearly one foot high. Profusely illustrated. Supplemented by valuable test questions.

This book shows how to attack systematically and logically the design of a complete machine and to provide the parts to meet specific conditions.

The *general method* of design is aimed at rather than the specific and individual cases. The simple and familiar component parts of machines are treated along the lines of Analysis, Theory and Practical Modification under the titles of Belts, Pulleys, Shafts, Spur Gears, Bevel Gears, Worm and Worm Gears, Friction Clutches, Couplings, Bolts, Studs, Nuts, Screws, Keys, Pins, Cotters, Bearings, Brackets, and Stands. Mention POWER, Dec., '07.

Regular Price, $2.00 Special Price, $1.50
Sent on 5 days' approval, express prepaid. Money refunded on request.

AMERICAN SCHOOL OF CORRESPONDENCE, Chicago, Ill.

1866 1907

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO. HARTFORD, CONN.

FORTIETH ANNUAL STATEMENT.
JANUARY 1st, 1907.

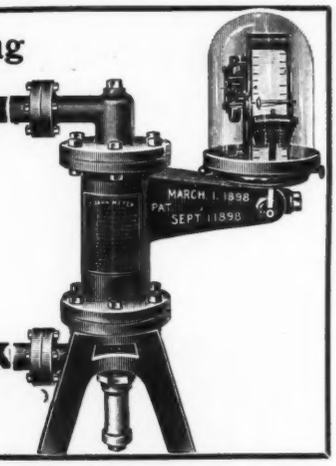
Capital	$ 500,000.00
Surplus	1,485,457 73
Reserves	1,992,787.98
Assets	3,978,245.71

The HARTFORD was the PIONEER Company in the field of steam boiler insurance and it is the only company which makes a specialty of and does exclusively a steam boiler inspection and insurance business.
The HARTFORD is the only Company whose entire talent and energy are applied to the study of steam, to the scientific construction and installation of boilers and to their periodical inspection by expert mechanics
The HARTFORD is now doing nearly $\frac{1}{10}$ of the inspection and insurance of steam boilers in the New England States, and nearly $\frac{2}{3}$ of the entire amount done throughout the United States.

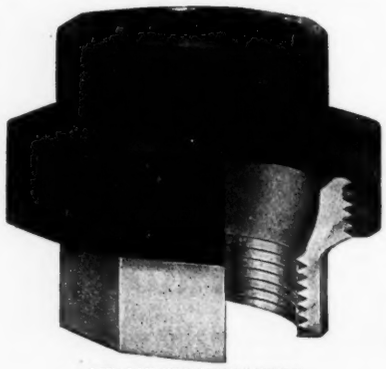
Steam Accounting

The St. John Indicating and Recording Steam Meter is an expert steam accountant.
Keeps a daily record every day year after year, and its dial will tell you any minute what you are delivering.

Want the Details?



G. C. ST. JOHN,
140 Cedar St.,
New York.



OCTAGON "KEWANEE" UNION

EASY TO MOVE
The Octagon "Kewanee" Union.
BECAUSE It has

Brass to Iron Thread Connection. Cannot Corrode. Brass to Iron Ball Joint Seat. No Gasket Required. Octagonal Form. Moved with a Common Wrench. Rigid Test before shipment. Compressed Air under water.

THEREFORE

The Octagon "Kewanee" Union is even after long service. *Write for Circulars.* **EASY TO MOVE**

Manufactured by Western Tube Company,
Kewanee, Ill.

THIS LABEL ON PACKING "EUREKA" TRADE MARK. IS A GUARANTEE OF EXCELLENCE.

"IF THAT LABEL

is on the box and packing, you can bank on it's being the very best for all ordinary engine and pump purposes. I have tried all others during the past 20 years and finally came back to 'EUREKA'" So writes one of our old customers.

Here is What Some Others Say:

"It will hold on a scored rod a long time."
"Never becomes hard or dry—without a peer."
"We have used it for years on twenty-three (23) engines and twenty (20) pumps."
"One box lasts us two years on our water wheel."
"It is especially good on Steam Hammers."
"My steamship made nearly two round trips to Havana with only one turn to follow up on H. P. Rod."
"I use it on all my rods including ammonia rods."
"It has no equal where service and economy are considered."
"I use it on 300 revolutions and 120 pounds steam and it's all right."

Isn't it up to You to Try "EUREKA"?

Make Sure it is Genuine Eureka.

Your Dealer Will Supply You.

Eureka Packing Company

Sales Department

Jas. L. Robertson, Pres't **46 Warren St., New York**

"AGRIPPA"

NEW FITTINGS-WRENCH.

Dealer privileged to give you one on trial!

A tool of unlimited value in placing short nipples and flanges and fittings with varied outlets.

A satisfactory tool on all kinds of pipe work. Will increase working and time-saving value of your kit one-third. All wrought steel, fully guaranteed.

J. H. WILLIAMS & CO.,

Mfrs. of "Vulcan" Chain Pipe Wrenches and Vises and Superior Drop-forgings

Brooklyn and Chicago

Try our facilities for heavy "to order" forgings. Special quality, etc., inducements to join our camp. Get catalog "P R."

You Can Use All The Force You Like On a "TRIMO" PIPE WRENCH

without feeling that you are damaging the pipe; that you are likely to slip and hurt yourself or that the Wrench may break.

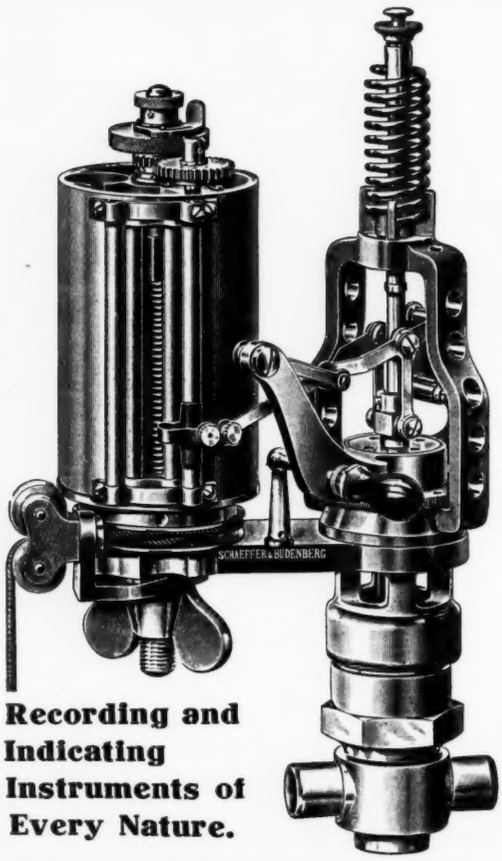
A few reasons for "TRIMO" superiority are: The INSERTED JAW in the handle can be easily and cheaply replaced, thus saving 25% of the Wrench, and lengthening life of Wrench indefinitely; no springs to break; the MOVABLE JAW is reinforced, giving added strength where others are weak; finest Steel is used throughout.

Those features make "TRIMO" Pipe Wrenches the strongest, most endurable, most reliable, and therefore the most economical on the market. Try them in your plant.

Send for Catalog No. 21.

TRIMONT MFG. CO.,

Roxbury, Mass., U. S. A.



Recording and Indicating Instruments of Every Nature.

What do you say to trying the most perfect, most practical indicator for Steam or Gas Engines?

The Improved Thompson Indicator With Outside Spring and Continuous Diagram—Pattern 1906—

is such an indicator. The outside spring allows quick changes—carries a strip of paper 10 feet long. The roll of paper may be removed without detaching indicator from the engine. Our *new Catalog* is worth *your* perusal.

The Schaeffer & Budenberg Mfg. Co., Works, Foxboro, Mass.

Salesrooms and Offices, 23 Dey St,, New York. 15 W. Lake Street, Chicago.

WE sell machinery and **HAVE** all kinds of good **MACHINERY** at such a price **THAT** will at least encourage **YOU** to figure with us on what you **WANT.**

We buy and sell New and Second-hand Machinery, Engines, Boiler, Pumps and Compressors. Let us figure with you.

CHAS. H. JONES & CO. 510 Monadnock Block, CHICAGO.

Known Round the World

A SAMPLE ON REQUEST.

Branches: New York City, Chicago, Ill., San Francisco, Cal.

U.S. METAL POLISH — G. W. Hoffman, Sole Prop. 295 E. Wash. St. INDIANAPOLIS, IND. — TRADE MARK — INFALLIBLE — FOR POLISHING GOLD, SILVER, PLATED WARE, NICKEL, TIN, BRASS, COPPER, Etc. — DIRECTIONS: Take a little of the Polish on a soft cloth, rub the Metal hard and then wipe it off with a dry cloth.

It has no competitors where the Best is known

3-oz. Box 10 cts. 5-lb. Pail, $1.00 1-gal. Liquid, $1 00. At Dealers.

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GEO. W. HOFFMAN—Expert Polish Maker

MACHINE SHOP ARITHMETIC—New Edition.—Price 50c.
Shows how all shop problems are worked out and "why." Includes change gears for cutting any threads; drills, taps, shink and force fits, metric systems of measurements and threads.

ENGINEER'S ARITHMETIC.—Price 50c.
Shows how to work the problems of the engine room and shows "why." Has steam tables and a lot of other useful information that makes it popular with practical men.

AMERICAN STATIONARY ENGINEERING.—Price $2
by Crane—Begins at the boiler room and takes in the whole power plant. Has a complete examination for a license.

Copies of these books sent prepaid on receipt of price. Our catalog sent free on request.

THE NORMAN W. HENLEY PUBLISHING CO., 132 Nassau St., N. Y.

Foster Superheaters

Greatly increase capacity and permanent efficiency of turbines.

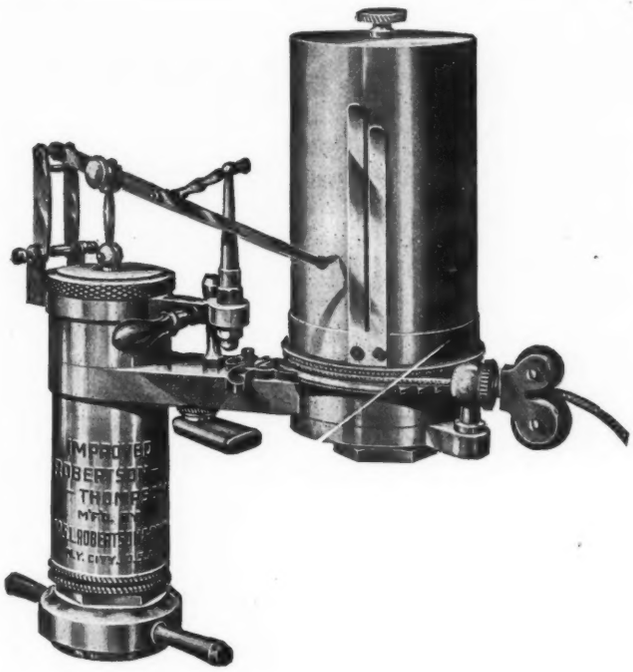
POWER SPECIALTY CO., 111 BROADWAY, NEW YORK.

It costs money to stand under a steady drizzle of dirty oil and water—costs more than a **Sterling Exhaust Head**—which do you prefer?

Catalog?

Good air will do wonders in a shop and it is so easy to install **Sterling Ventilators** which insure good air. Shall we send prices and particulars?

STERLING BLOWER & PIPE MFG. CO., 6827 First Avenue, HARTFORD, CONN.—New York Office: 109 Liberty Street.



YOUR SUCCESS

Depends Upon What You Know

A Robertson-Thompson Indicator

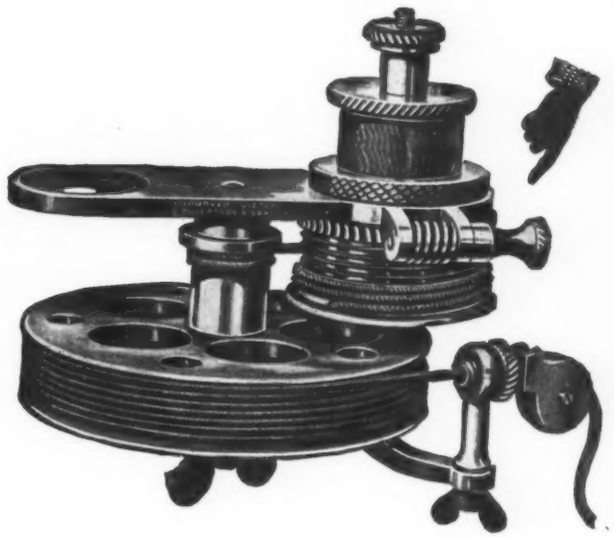
will tell you more about your Engine—more about things you are responsible for than by any other means.

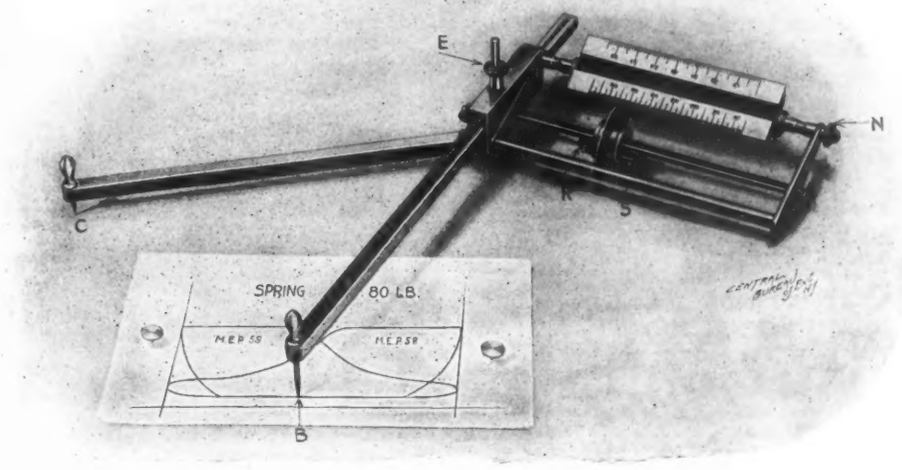
There is a place waiting for the man **WHO KNOWS** and an **INDICATOR** will tell you what you ought to know.

Moderate Prices and Easy Terms Make Easy Buying

A Victor Reducing Wheel

is adapted to all makes of indicators. Gives a perfect reduction without lost motion. Can be connected to Engine while in motion. Note the patented spring tension. A device much appreciated.





AN IMPROVED Willis Planimeter

completes an Engineer's Outfit.
Reads the M. E. P. direct without liability to error.

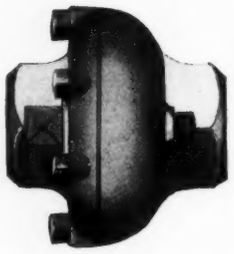
Jas. L. Robertson & Sons, 46 Warren St., New York

LUCAS PNEUMATIC TUBE EXPANDER

SAVES TIME AND LABOR

Operated by pneumatic hammer. Works easily; pins will not stick. Can be turned readily by the operator. Does perfect work. Cannot injure flues or sheet. Saves 50% to 75% of labor, expanding new tubes perfectly at the rate of 100 per hour. Made of high-grade tool steel and guaranteed. The price is reasonable and we will send it on trial to responsible parties.

EVERLASTING BLOW-OFF VALVE



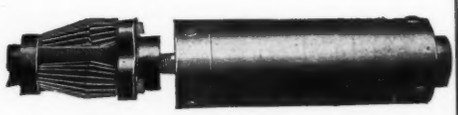
Straight-through flow. No stuffing box. Easily operated. Self-cleaning; self-grinding seats. Easily repaired. Guaranteed for two years' continued and uninterrupted satisfactory service. Send for descriptive booklet and prices.

SCULLY STEEL & IRON CO.

CHICAGO.

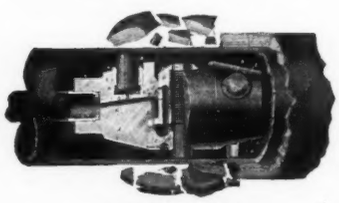
Unique, Modern, Money Saving, Scale Removers All Three of These

The *"Demon"* straight tube cleaner is *guaranteed* to remove any thickness of scale. It does more *work, better,* than several turbines all working at the same time. If you'll put the "Demon" to work you'll have *clean* boilers, not boilers "nearly" clean. Send for one on trial, if it does not "make good"—keep your coin and return the cleaner. You can't lose.



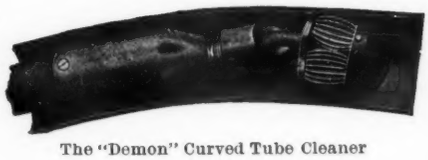
The "Demon" Straight Tube Cleaner

Is it any wonder that scale cannot stand over 11,000 vibrations passed through it a minute? This is the secret of the success of the "Torpedo" Cleaner. It removes the scale from the common return tubular or fire tube boiler with a thoroughness that is a delight to hundreds of Engineers. The one enemy that scale falls before—the *"Torpedo"*—triumphs every time. *Try it, then you'll know.* Write for circular No. 30. How to tell a good fire tube cleaner.



The "Torpedo"

Here's the curved tube cleaner of the hour—the *"Demon"*. A Piston not a turbine motor. The hardest scale cannot "feaze" it one particle. *A fifteen days' free trial* will prove how fast it works under the most adverse conditions

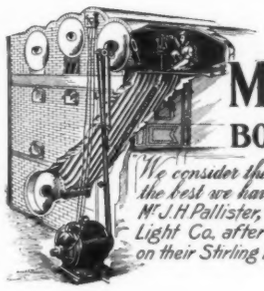


The "Demon" Curved Tube Cleaner

Ask for our Circular and Free Trial Proposition—Today is a good time.

THE GENERAL SPECIALTY COMPANY,

887 Niagara Street, BUFFALO, N. Y., U. S. A.



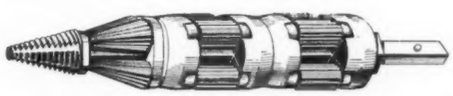
THE WEINLAND MECHANICAL BOILER TUBE CLEANER

"We consider the investment in that machine one of the best we have ever made" — Statement of Mr. J. H. Pallister, Chief Engineer Vicksburg (Miss.) Ry & Light Co. after using the Weinland Mechanical Cleaner on their Stirling Boilers for five years.

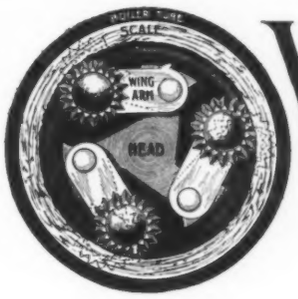
That the Weinland Mechanical Cleaner will do as good work in curved tubes as in straight tubes and with the same ease is proven by the following further quotation from Mr. Pallister:

"The last time we used it in our No. 3 Stirling Boiler, which has 233 tubes, we did the work in just 33 hours although the 54 in the rear bank were nearly filled with very hard scale. All the tubes were in very bad shape. I figure that we saved not only the price of the tubes, but the delay and bother in taking out the old ones and putting in the new.

"Your tube cleaners are the best and most efficient I ever used. The power machine is good as new."



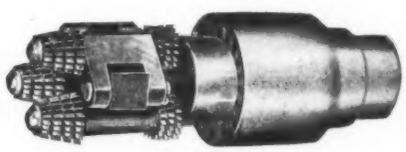
We rent the machine with privilege of purchase, or will clean the boilers for you. After overhauling with the Mechanical Cleaner you can keep the boilers clean with the Weinland Thrust Bearing Turbine.



THE NEW WEINLAND WING ARM TURBINE BOILER TUBE CLEANER

Our new Wing Head does a thorough job without hurting the tubes. The cutting stars are carried by heavy hinged wings so that centrifugal force throws them out stiffly against the scale. From the end view you will see that the cutters are pushed into the scale instead of being merely dragged over it.

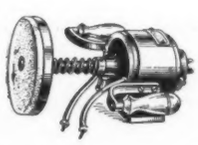
The thicker the scale, the harder the cutters dig. The Weinland Wing Head is the only boiler tube cleaner of which this is true.



Patented.

Others have copied the Weinland turbine, but they didn't get the latest improvements.

Weinland Wing Head Cleaners are for ordinary and light scale. For hard scale or where there is much cleaning, use the Weinland Mechanical Cleaner, driven by a 3 to 30 h. p. engine, or motor, as necessary.



The Lagonda Reseating Machine

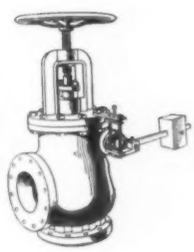
Cleans the faces, caps and nuts of B. & W. and similar boilers sixteen times as fast as by hand. Driven by electric or water motor.

The Lagonda Boiler Tube Cutter

Will make a slick, clean cut in a four-inch tube in one minute.
By using an extension shaft it will cut at any point of the tube and is always ready for use.

The Lagonda Automatic Cut-Off Valve

Protects boilers and men. If a header bursts it stops off the boilers. If a tube bursts it cuts out the defective boiler wifhout shutting off the others. Steam cannot flood the boiler room to destroy property and lives.



The Lagonda Manufacturing Company,

SPRINGFIELD, OHIO.

New York Boston Philadelphia Pittsburg 38 Chicago Toledo St. Paul San Francisco

With Half A "Hawkeye"

you can see the end of Scale

No matter how bad the water **Hawk-Eye** Compound will remove the scale and prevent the formation of more.

Hawk-Eye contains *no acid* and is twice as effective per ounce as any other.

Hawk-Eye is made up in dry block form and marked off in one-pound squares and is very nice to handle.

We are experts in the manufacture of boiler compounds and make them to order for our customers, suitable for the water and conditions at their plants.

This is the only compound company in the U. S. which does not manufacture or sell anything but boiler compounds and we must make good or fail.

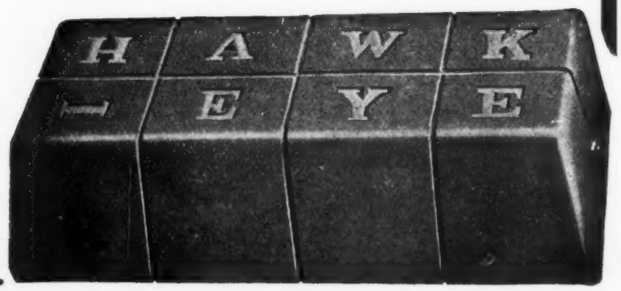
We deal directly with the consumer only.

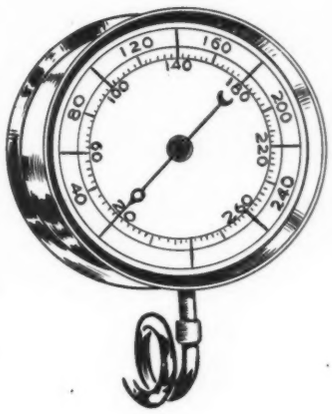
We loan our customers a device for injecting **Hawk-Eye** into the water. Write for details.

Hawk-Eye Compound Company,

303-304-305 Merrick Block,

Phone, Wentworth 135. **CHICAGO, ILL.**





The Safety of Your Property And The Lives of Yourself and Men Depend on Clean Boiler Tubes More Than On The Amount of Pressure Shown on Your Steam Gauge.

One-tenth the amount of steam that can be carried in a clean boiler with perfect safety can wreck your plant through the burning out of tubes insulated from the water by scale.

Dearborn Feed Water Treatment

not only does away with and prevents further scale from forming, but preserves the tubes from rust or corrosion of any kind.

We *analyze* your feed water and prepare the treatment just as carefully as any first class druggist makes up a prescription.

DEARBORN DRUG AND CHEMICAL WORKS

WH. H. EDGAR, Founder.

LABORATORIES AND WORKS, CHICAGO.

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San Francisco, 301 Front St.
Buffalo, Morgan Bldg.
Kansas City, New York Life Bldg.
Milwaukee.
Los Angeles, 355 E. Second St.
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Peoria.

FREE FREE

Would You Like One To Slip in Your Pocket?

It will cost you nothing to secure this handy little device—used a hundred times a day. It's a friend in need—a combination Key Ring, Screw Driver, Cigar Cutter, Punch, Nail Cleaner, etc., Carry it in your pocket and be prepared for sudden emergencies. It looks good and "makes good".
Here's how to get it. Send us a sample of scale from the inside of your boiler and answer the questions given below. We'll then mail you the "LITTLE FRIEND IN NEED" and also send you valuable points regarding boiler cleaning. No telling how long we can supply the demand. So write at once.

Your Name and Address?
Name and Address of Firm Owning Boilers?
How Many Boilers and Horse Power of Each?
How Often Opened for Cleaning?
Hours Run Daily and Name of Compound Used Now?

BINGHAMTON BOILER COMPOUND CO.

WATER PURIFYING CHEMICALS.

BINGHAMTON NEW YORK

Offices

LOS ANGELES, CAL.
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SYRACUSE, N. Y.
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BIRMINGHAM, ALA.

WARREN'S BOILER COMPOUNDS

Is it sense to knock and jar and scrape the life out of the tubes with mechanical cleaners or waste time with *ordinary* boiler compounds?

Decidedly not! Then remove the trouble by using Warren's Boiler Compounds. Warren's Compounds effect a permanent cure in over 90 per cent. of the cases treated.

A fair trial is all we ask. Warren's Compounds are the most effective, the most economical and the best. They *hit the spot* because they are true and exact combinations; not mere mechanical mixtures. Write for our circular.

THE WARREN CO., Mfrs.,
257 N. FRANKLIN ST.,
CHICAGO.

PURE WATER FOR THE BOILERS BY THE

WE-FU-GO and SCAIFE

Water Softening and Purifying Systems.

RESULTS GUARANTEED SEND FOR OUR CATALOG.

WM. B. SCAIFE & SONS CO.,

Founded 1802. PITTSBURG, PA.

Taylor's Spiral Riveted Steel Pressure Pipe.

Best steel pipe made for Hydraulic Purposes. 3 to 40 inches diameter.

AMERICAN SPIRAL PIPE WORKS,

Main Office & Works: Chicago, Ill. Eastern Office: 39 Cortlandt St., New York.

STARRETT TOOLS

For Machinists, Millwrights, Carpenters, Draughtsmen, Jewellers.

Send for free Catalogue —No. 17 AG—and new Supplement, 192 pages, showing the largest line of Fine Mechanical Tools.

THE L. S. STARRETT COMPANY,
ATHOL, MASS., U. S. A.

We Guarantee To KEEP Your Boilers CLEAN.

We Guarantee:

To remove all scale and incrustations.

To remove all oil and grease.

To wholly prevent the accumulation of new deposits of scale and grease.

To arrest every form of internal boiler corrosion

AND

To accomplish these results *with absolutely no injury* to the boiler or its fittings, without causing foaming or priming and without interfering with cylinder lubrication, by the use of

BIRD-ARCHER'S BOILER COMPOUNDS

We guarantee complete results wholly satisfactory to you, or *no pay.*

Such a guarantee ought certainly to convince you of our sincerity and ability, because we couldn't make such an offer if we couldn't *surely* make good.

Our boiler compounds have no "marvelous discovery" features, none of the patent medicine "potent principle of a rare herb discovered by Doctor So-and-So in the mountains of Timbuctoo, etc."

Bird-Archer's Boiler Compounds are prepared under the supervision of skilled analytical chemists and contain *only such ingredients as chemical analysis shows are demanded to neutralize the deposit-forming matter of the feed water in question,* and to render it harmless. Like a wise physician's prescriptions, our Compounds are designed to cure—not all ills—*but the specific ailments of the individual.*

That's why we can issue our sweeping guarantee.

That's why our customers get the results they want.

If you have trouble write us for a remedy.

COPY THIS

The Bird-Archer Company
Referring to your advertisement in December POWER please send a copy of your book for Steam Boiler Users—"Ten Questions" and one of your free trial order forms.

Name.....

Address.....

Employed by.....

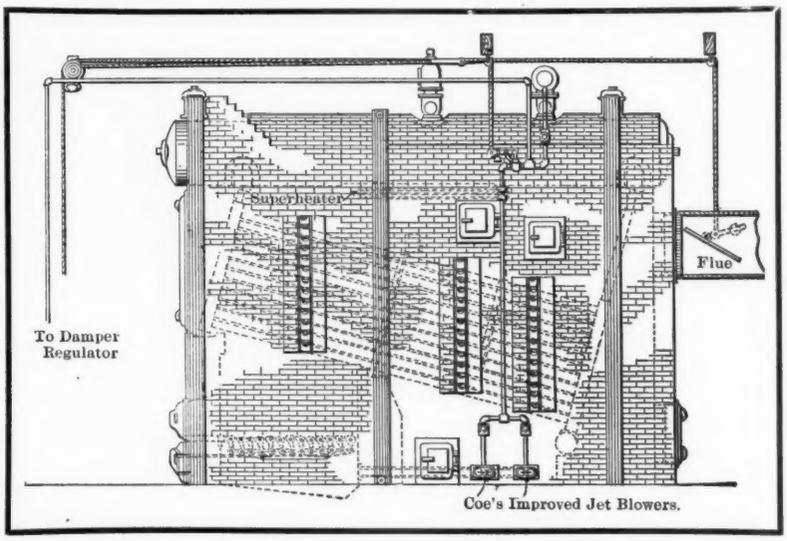
The BIRD-ARCHER COMPANY,

90 WEST STREET, NEW YORK.

BRANCHES:

Pittsburg, 506 Fulton Bldg.
Norfolk, Va., 22 Campbells Wharf.
New Orleans, La., 3215 Canal St.
Easton, Pa., 1st National Bank Bldg.
Cleveland, O., 403 Cleveland Arcade.
London, England, Billiter Bldg., E. C.
San Francisco, Cal., 24-26 Steuart St.
Boston, Mass., 7 Water St.
Philadelphia, Pa., 56 North Delaware Ave.
Baltimore, Md., 324 N. Holliday St.
Chicago, Ill., 501 Monadnock Block.
Havana, Cuba, O'Reilly 67.

The Coe System Guarantees A Fixed Percentage Of Economy



DO YOU WANT MORE STEAM PER POUND OF COAL?

DO YOU WANT TO BURN CHEAPER COAL AND REDUCE YOUR POWER COST?

We can equip you with the Coe Balanced Draught Combustion System and give you both these results. Superheated steam is forced throught the fire by means of a jet blower located in the back or side wall, the operations being controlled by an automatic balancing device which regulates the forced draught and damper.

Specially designed sectional rocking grate bars are used which permit the economical consumption of low grades of anthracite or mixed soft and anthracite coals, accomplishing almost complete combustion, as shown by the very small ash residue.

Notify us and we will send an expert to look over your special conditions and make a guarantee of a fixed percentage of economy obtainable by the installation of the Coe System. If we do not realize our guarantee we will restore your boilers to their original conditions with no cost to you.

When shall our expert call?

Geo. H. Thacher & Co., Albany, N. Y.

ESTABLISHED 1852.

Selling Agents For Geo. H. Thacher & Co.,

Universal Grate Bar Co., 95 Liberty Street, New York.

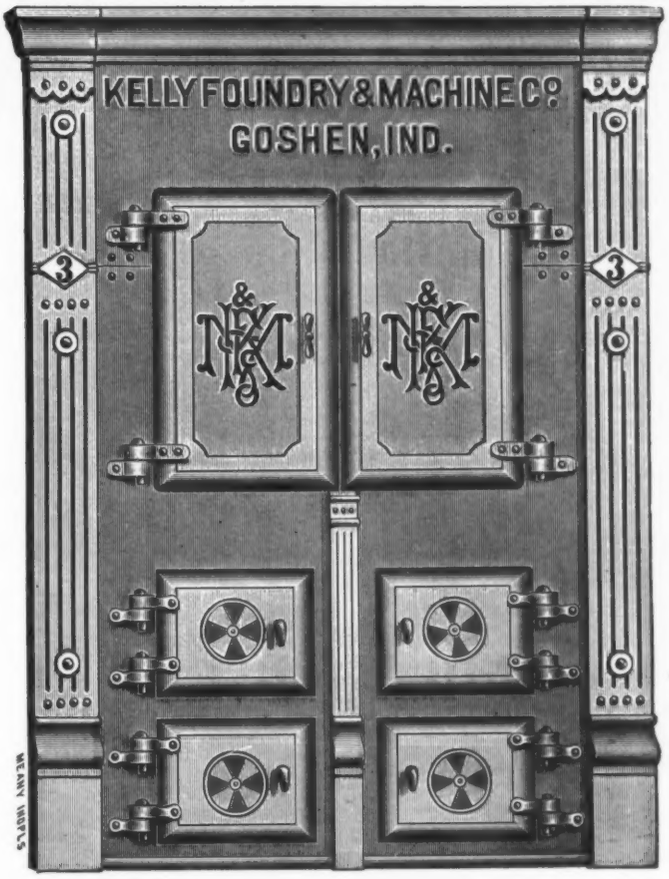
The Door of a Safe

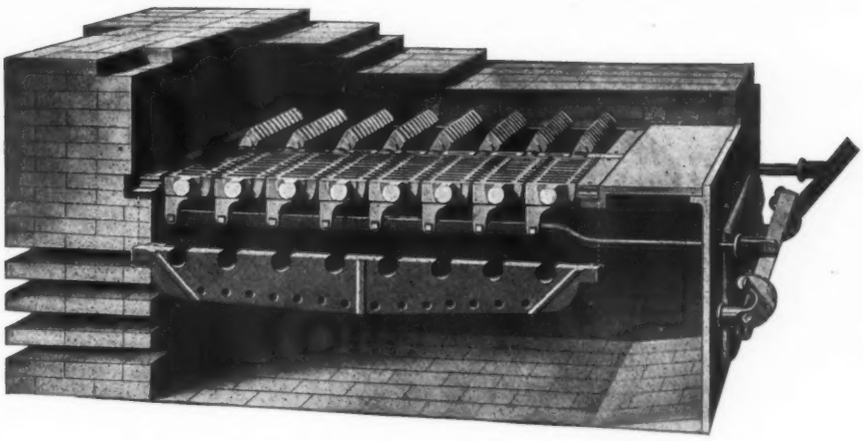
is no better or more carefully made for its purpose than our Boiler Fronts.

Our catalog shows a variety of designs at prices to suit almost any requirements. However, if you do not find what you want in our stock we will gladly figure on special designs.

Everything in cast-iron for boiler setting.

Catalog F.





Look into the Grate Question

THE KELLY ROCKING AND DUMPING GRATE dumps in sections providing the most perfect way of cleaning your fire.

You do not need to open the furnace door, let in cold air or roast your hands and face.

Burns any kind of fuel, is easy to install and gets the results. Makes the work of your firemen easier.

Write today for Grate Book K.

Kelly Foundry & Machine Company,
603-9th Street, GOSHEN, IND.

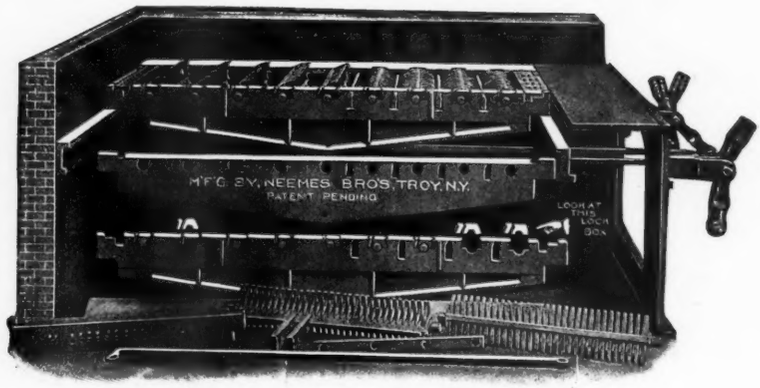
Boiler Fronts, Boiler Castings, Stationary Grates, Rocking and Dumping Grates, Etc.

More Steam=Less Coal=Less Trouble

With The

Neemes Grate

And



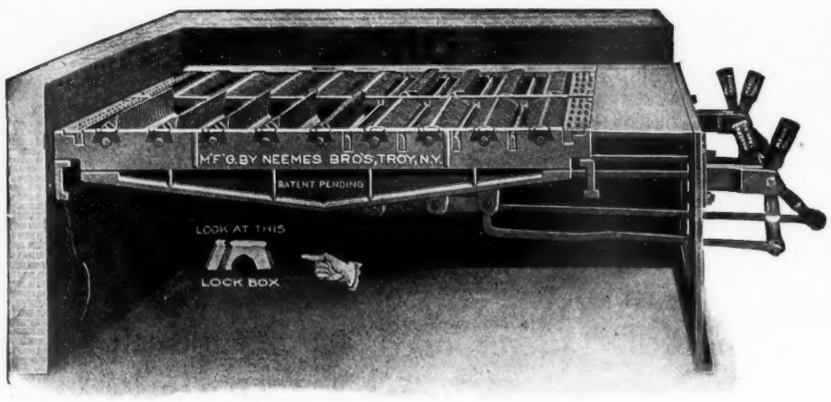
A Clean Even Fire From Front To Rear

Burns coal of any quality—thus *Saving Fuel Costs.*

Burns all the coal you give it—*Saves Stoking Cost.*

Burns nothing but the coal—*Saves Repairs.*

Burns cheap coal with better results than most grates produce with the more expensive fuels.



Fits Any Furnace Without Alteration Of Brickwork.

Write.

NEEMES BROTHERS, 41-49 ADAMS STREET, TROY, NEW YORK, U.S.A.

MANUFACTURERS OF SQUARE AND ROUND GRATES.

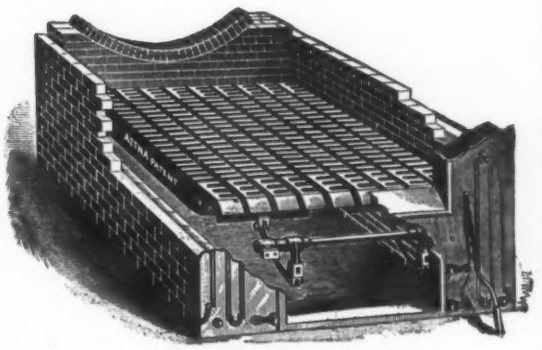
C. W. Van Blarcom, 126 Liberty St., New York City. Babcock & Wilcox, Ltd., Montreal, Canada, Sole Makers for Canada. Burke Engineering Co., 311 Industrial Trust Building, Providence, R. I., Sole Agents for the New England States. Cass Harkins, Hayden Building, Columbus, Ohio.

Burning Money

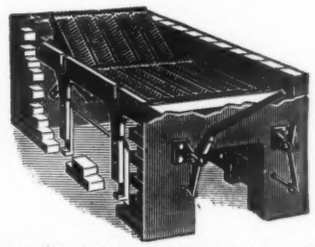
Does Not Make Profitable Steam.

These Grates Burn Fuel and Save Money.

The "Aetna" burns every grade of hard or soft coal from pea coal up, burns it clear and at a steam profit of from 5 to 20%. It is self-supporting, easily operated and long lived. Can refer to users for ten years without repairs. Does not require an open furnace door to clean the fire. A large percentage of air space is one of its good points.



AETNA SHAKING GRATE.

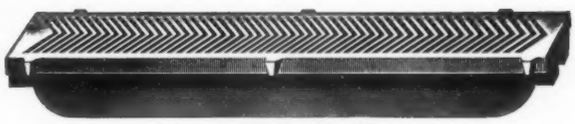


SALAMANDER DUMPING GRATE. With ¼" or 5/16 openings, this grate is adapted for burning the finer grades of anthracite coal from No. 3 Buckwheat up.

The Salamander Dumping Grate can be easily and quickly placed in the furnace without disturbing the brick work. With this grate a great saving in fuel can be had and fires can be cleaned in five minutes. The top sections, should occasion require, can be replaced at short notice and with little expense. This is one of the best grates on the market.

The Salamander Interlocking Stationary Grate Bars have been used in over 10,000 furnaces. They have been on the market over 50 years and are the longest lived stationary bars ever put in a furnace. Made for square and round furnaces.

INTERLOCKING GRATE BARS. Salamander Interlocking Grate Bars on the market over 50 years. Longest lived stationary bar ever put in a furnace.



ROGERS GRATE.

Any draft opening from ¼ inch up can be had with the Celebrated Rogers Grate. This grate is unequaled for burning fine and waste fuel. Long lived and moderate in price. We guarantee to give perfect satisfaction with this grate as well as all our other grates.

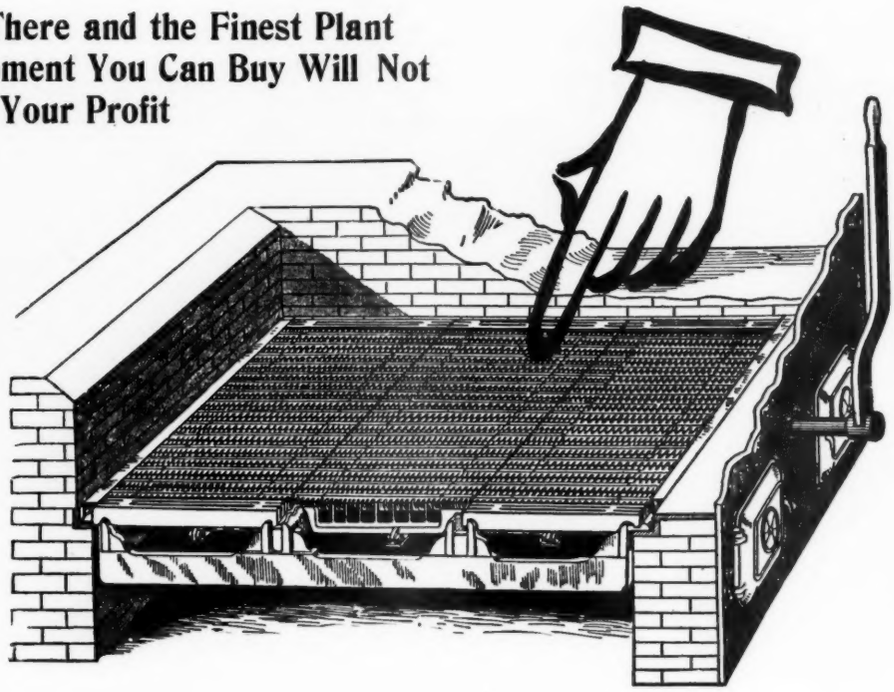
We make over 20 different styles of grates. If you don't see it here, we can make any kind of grate you require from our special mixture of iron, which we guarantee will last twice as long as ordinary foundry grates.

Salamander Grate Bar Company,

126 Liberty Street, Telephone 4136 Cortlandt **New York, N. Y.**

There's the Point!

Fail There and the Finest Plant Equipment You Can Buy Will Not Save Your Profit



You may have the finest engines, pumps and other plant fixtures that money will buy and yet a poor grate will spell failure to your entire plant.

We know how to build grates that save money by burning any kind of fuel, however cheap, and getting the results you would expect from high priced coal.

The Martin Grate can be installed in any furnace without alteration of the fire-box.

Write for catalog and list of users.

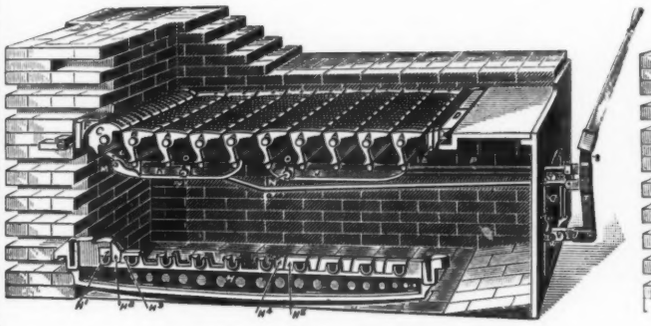
The Martin Grate Company,

281 Dearborn Street, Chicago, Ill.

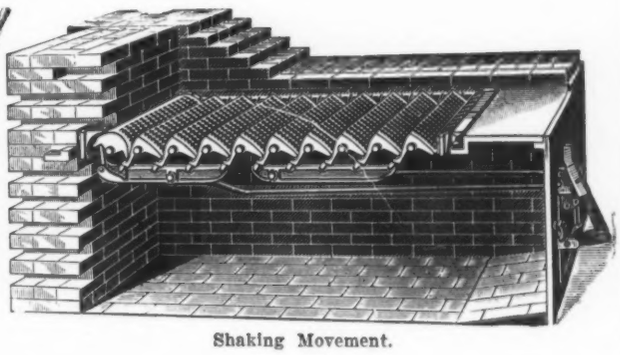
The McClave Grate and Argand Blower

Argand Steam Blower.

Solve the Fuel Question Most Profitably.



Normal Position of Grate.

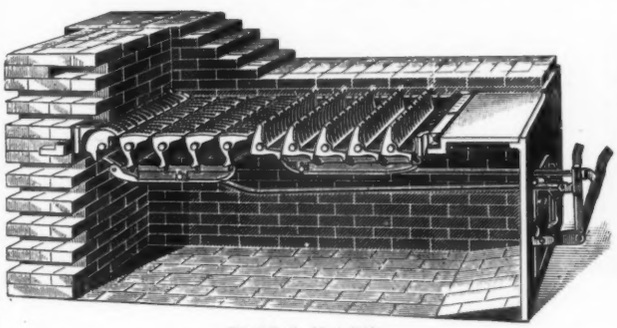


Shaking Movement.

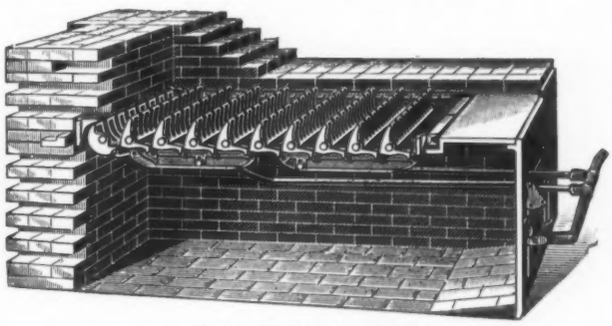
An Even Fire Assured With McCLAVE GRATES

Because they are made with various sized meshes to suit the particular kind of fuel used. The McClave takes any kind of fuel—burns it *all*—thus getting every possible heat unit out of it. More power and lower fuel cost the result. The McClave Grate and McClave's Argand Blower will settle the fuel question most economically and on that account, satisfactorily. First grade results with inexpensive fuel because built with that end in view.

Let us forward Catalog "D" which sifts out the Grate question thoroughly.



Divided Cut-Off.



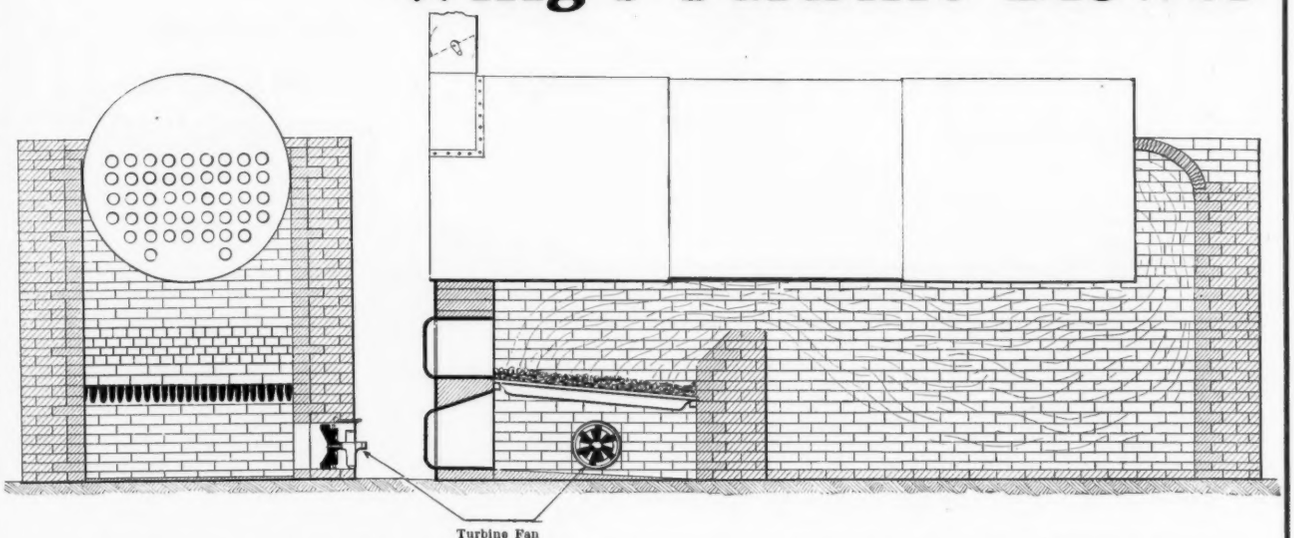
Whole Cut-Off Movement.

McCLAVE-BROOKS COMPANY,

SCRANTON, PENNSYLVANIA.

BRANCH OFFICES: Charles N. Hayes, Sales Agent, 1611 Fisher Building, Chicago; 1106 Empire Building, Pittsburg.

True Economy Is Taught By Wing's Turbine Blower



Turbine Fan

Mechanical Draft is the Proper means of keeping your furnace and boiler efficiency *up* and your fuel and expense bills *down*.

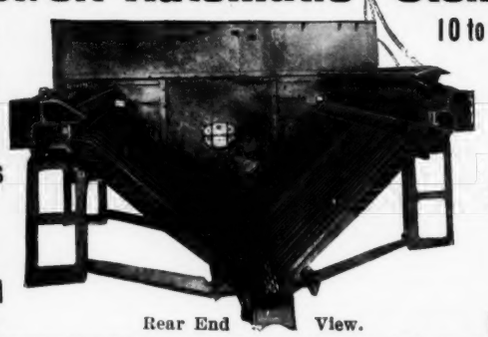
Our system is IDEAL. It permits the burning of a cheaper grade of fuel, insures *complete* COMBUSTION of same, adds years of life to the boiler and takes the place of the old style large blower and engine. Easily installed; no trouble, no clinkers. Write for a catalog.

L. J. WING MFG. CO., 90 WEST ST., Cor. Cedar, **New York.**

MFGRS. WING'S DISC FANS, BLOWERS AND EXHAUST FANS. Combustion and Ventilating Engineers

Detroit Automatic Stoker

Feeds and Burns Coal and Cleans the Fire with Closed Doors



Rear End View.

10 to 25 % Less Fuel

Fits all Styles and Sizes of Boilers

DETROIT STOKER & FOUNDRY COMPANY, Detroit, Mich.

BRANCH, CINCINNATI, OHIO.

JEFFREY "CENTURY" RUBBER BELT CONVEYORS

Are adapted for handling many kinds of material in either packages or bulk

Elevating	Screening
Conveying	Crushing
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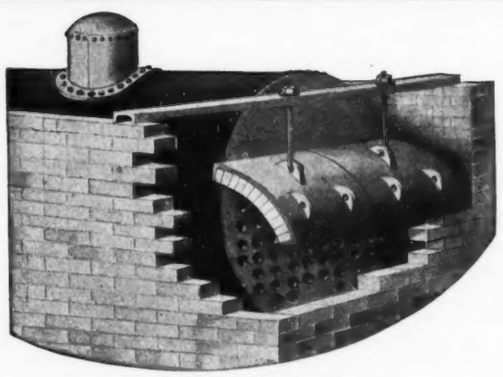
Catalogs Free.
Correspondence Solicited.

THE JEFFREY MFG. CO.
Columbus, O., U. S. A.

New York, Chicago — Boston, Pittsburg — St. Louis, Denver — Knoxville, Charleston, W. Va. — Montreal, Canada.

If Your Boiler Is A Good One, It May Last As Long As The MONARCH BOILER ARCH



No Bolts or Fasteners.

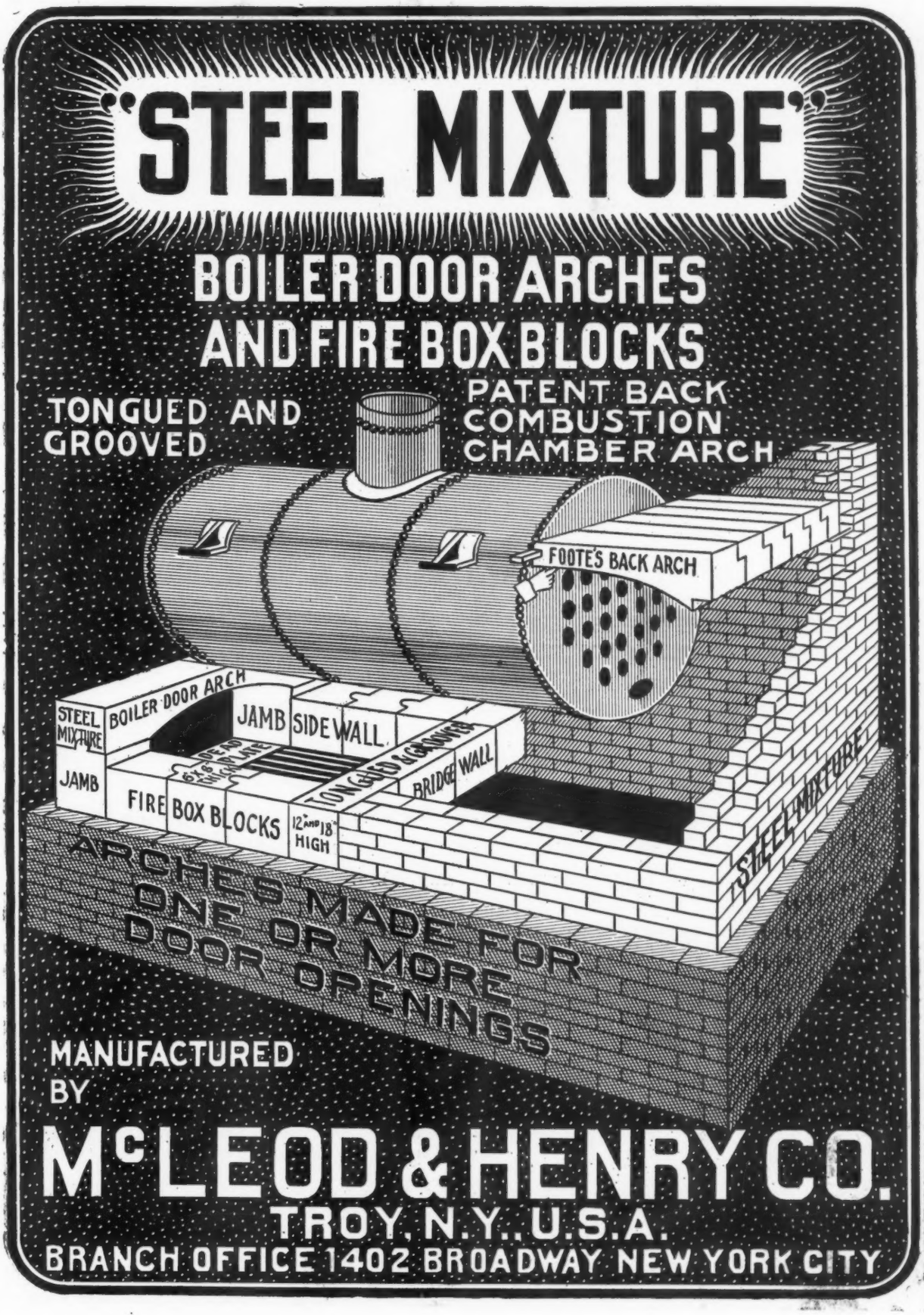
ADVANTAGES OVER THE OLD-FASHIONED ARCH:

Saves time and trouble. Easy to remove or replace. Does not expand and force brick work out of place. Money back if you want it.

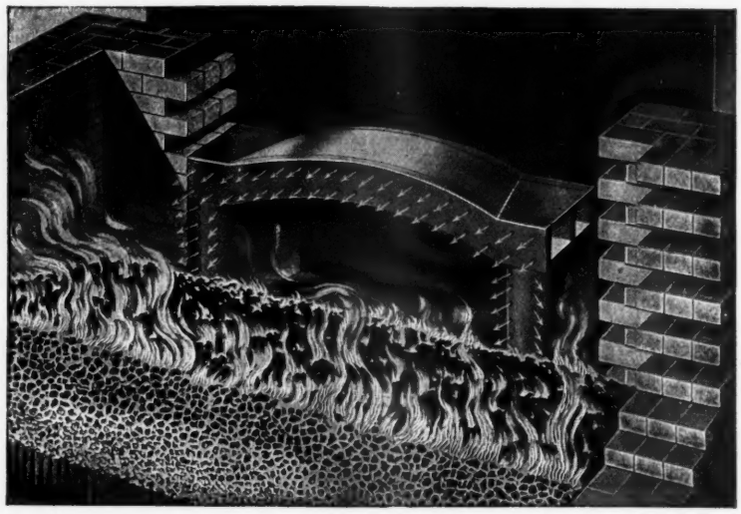
When writing for prices, give size of boiler, distance between side walls and distance from rear boiler head to rear wall.
We also make a *front* or "fire door arch."

Catalog?

MAYVILLE SPECIALTY MFG. CO.,
General Founders and Machinists,
MAYVILLE - - - WISCONSIN.


"STEEL MIXTURE"
BOILER DOOR ARCHES
AND FIRE BOX BLOCKS
TONGUED AND GROOVED
PATENT BACK COMBUSTION CHAMBER ARCH
FOOTE'S BACK ARCH
STEEL MIXTURE
BOILER DOOR ARCH
JAMB
SIDE WALL
JAMB
FIRE BOX BLOCKS
12" AND 18" HIGH
TONGUED & GROOVED
BRIDGE WALL
STEEL MIXTURE
ARCHES MADE FOR ONE OR MORE DOOR OPENINGS
MANUFACTURED BY
McLEOD & HENRY CO.
TROY, N.Y., U.S.A.
BRANCH OFFICE 1402 BROADWAY NEW YORK CITY

Argand Hot Air Diffusion Arches And Jambs



Are Money Savers And Smoke Abators

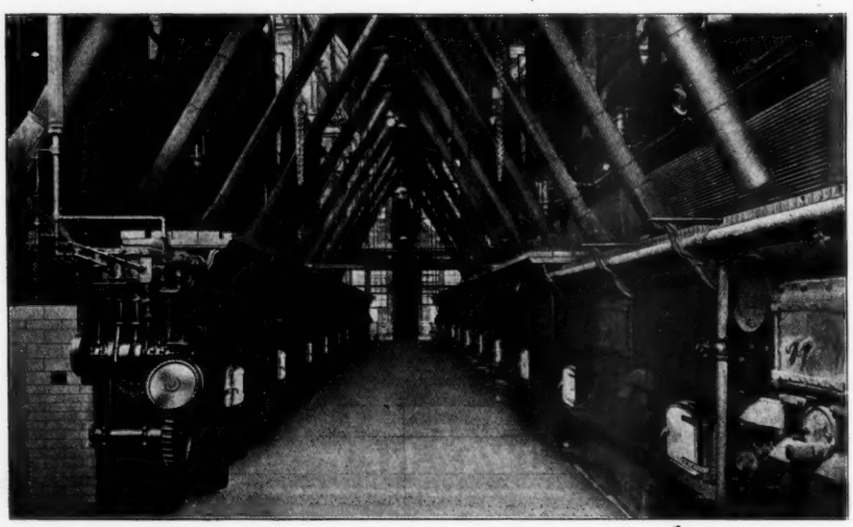
If you are interested in brick set steam boilers, in any way, it would prove to your interest and profit to get thoroughly posted regarding the "Argand." Send for our *Circular* which covers the subject in an instructive manner.

WILSON & ROAKE, 261 Front Street, New York.

The Murphy Automatic Smokeless Furnace

IS AS NEAR PERFECT AS A FURNACE CAN BE MADE

It burns all the coal, no matter how cheap it may be, and you get the benefit of all the heat. It is adaptable to any type of boiler and to units of any size.



Send For Descriptive Booklet.

Manufactured by

MURPHY IRON WORKS

5 WALKER STREET, DETROIT.

Branches in all large cities.

Green Traveling Link Grates
Are Smokeless and Labor Saving.

They operate automatically during all the progressive stages of feeding the coal into the furnace, lighting and coking it. With their use everything combustible is consumed and all refuse is discharged into the ash pit.
Get some particulars now—it will pay you to.

Over 700,000 Horse Power in use.

MANUFACTURED BY
GREEN ENGINEERING COMPANY,
Commercial National Bank Building, Chicago, Ill.
General Foundry Work a Specialty.

914

NORTHERN TRANSMISSION SYSTEMS
FIT OLD PLANTS AS WELL AS NEW.

The use of our product assures convenient, speedy, economical production. Our generators are readily installed in connection with old power plants. Our motors are easily applied to all classes of machine drives.

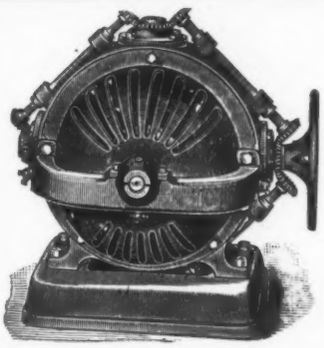
If you want us to discuss your requirements for electrical machinery, say what you plan doing electrically. Tell us at once so that our propositions and suitable literature may be in your hands for early consideration. Send for bulletin 3350.

NORTHERN ELECTRICAL MFG. COMPANY,
Standard and Special Electrical Machinery
MADISON, WIS., U. S. A.

USE OUR
Steam Blower

Patented Jan. 6, 1903 Another Patent Pending.

Manufactured only by
THE GIBSON IRON WORKS COMPANY,
Jersey City, N. J.



The Only Motor
for variable speed that is in itself complete.

The
Stow Multi Speed
requires no controller. Its speed is under perfect control by simply turning the hand wheel.

Full H. P. at all speeds.

BULLETIN 54.

STOW MFG. COMPANY, Binghamton, N. Y.
GENERAL EUROPEAN AGENTS
Selig, Sonnenthal & Co., 85 Queen Victoria Street, London, Eng.

Cruise Boiler Tube Protectors

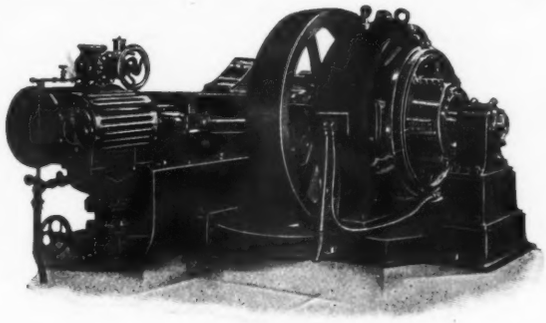
Reinforce Tubes at the point that is most likely to wear. A set of these protectors costs but a trifle and practically makes your tubes new. Circular on request.

CRUISE & COMPANY
144-150 Broadway, ELIZABETH, N. J.
Telephone Nos. 745R—526R.

Over 6000 Hammel Oil Burners
In use in Locomotives, Stationary Boilers, BrickKilns, &c.

C. A. HAMMEL, MFR. and PATENTEE,
609 North Main Street - LOS ANGELES, CAL.

Warren Electric Manufacturing Co.,
Manufacturers of
Inductor and Revolving Field Alternators,
"Wemco" A. C. and D. C. Motors.
Write for Bulletin No. 37.
Sandusky, Ohio.



Triumph Engine Type Generator.

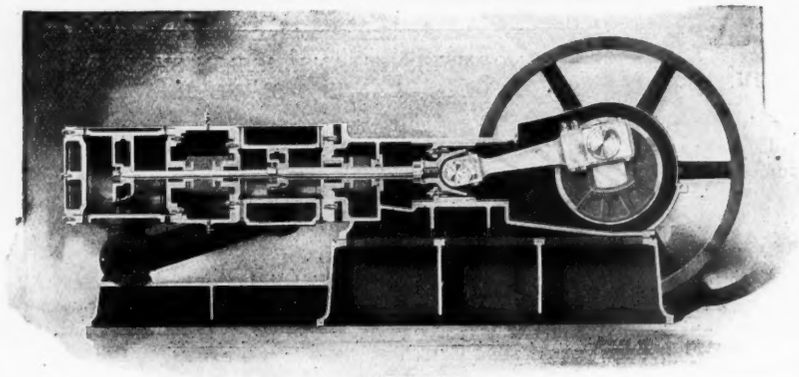
TRIUMPH
GENERATORS

will give you the best possible lighting and power service, while materially reducing your present expenditures for that purpose.

Thousands of them are now in satisfactory operation.

We want your inquiries. Bulletins **"P 241 and P 281"** sent on request.

Triumph Electric Company
Cincinnati, Ohio, U. S. A. Branches in all large cities.

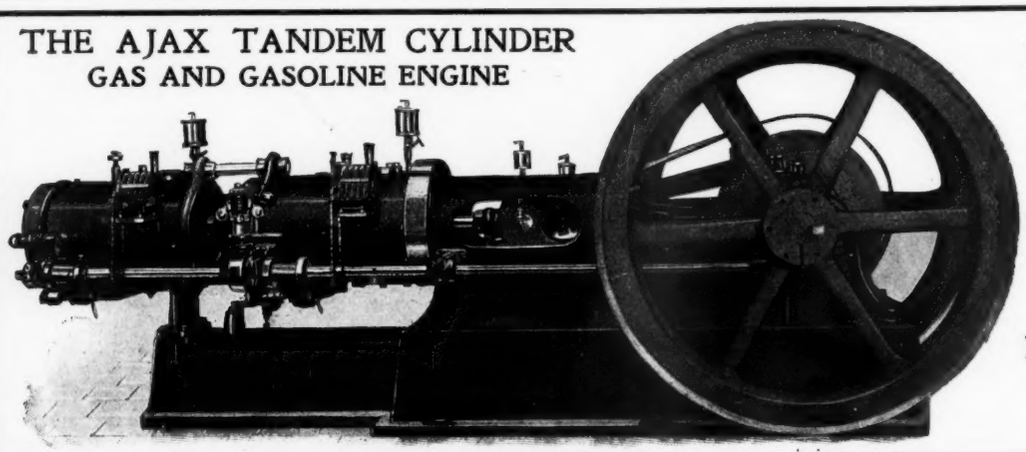


Horizontal Tandem Compound, class "A" type, showing cylinder arrangement and all interior working parts.

Buffalo Forge Co. Engines
are noted for
Simplicity of design
Marked economy of steam
Quiet running qualities

The Buffalo Forge Co.,
BUFFALO, N. Y.
DESIGNERS AND BUILDERS OF
High Speed Engines, Mechanical Draft Apparatus, Jet Condensers, Heating and Ventilating Apparatus, Steam, Centrifugal, Power and Turbine Pumps.
NEW YORK - - CHICAGO.
Canadian Buffalo Forge Co., Montreal, Canada.

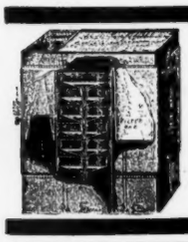
THE AJAX TANDEM CYLINDER
GAS AND GASOLINE ENGINE



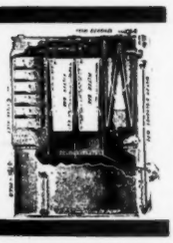
Built in sizes from 50 h. p. to 130 h. p.

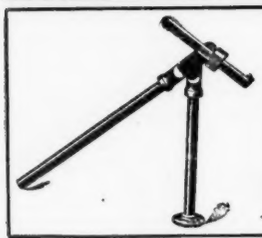
Catalogue on request.

AJAX
IRON WORKS,
CORRY, PA.,
U. S. A.



Send for Catalogue.
"EFFICIENT BEARINGS."
New departure in modern engineering. Contains also description of the
Famous-Franklin Oil Filters
5 to 5000 Gallons Per Day.
FRANKLIN FILTER COMPANY
306 N. Commercial St., St. Louis, Mo.



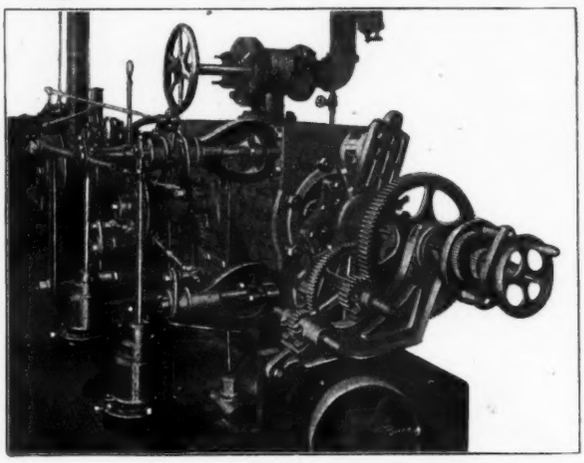


CHICAGO
ENGINE JACK
Will turn your engine off centre or from centre to centre in valve setting. Write for descriptive circular and prices.
McMaster-Carr Supply Co.,
178 Lake Street, CHICAGO.

We Guarantee
A 50% Saving
to those who use Amsler Gas Producer and Gas Engine System instead of steam.
Less in first, further and final cost.
Write for details.

Amsler Engineering Company, Pittsburg, Pa.

Put Us Wise To Your Engine Repair Troubles

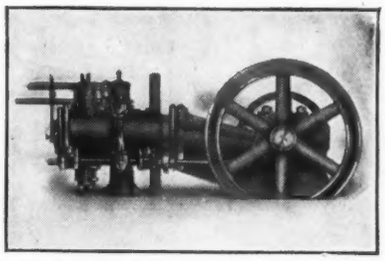


To get the *right* job, it all hinges on getting the *right people* to do it. As soon as you "put us wise," we'll have a competent engine expert to you in a jiffy with the necessary tools. All kinds of engine repair work executed *right* and *reasonably*. Call on *Underwood* next time—no matter where you are located.

H. B. Underwood & Company,
ESTABLISHED 1870.
1027 Hamilton St., Philadelphia, Pa., U. S. A.

Du Bois Gas Engines

"The Improved Type"



Single Cylinder-Throttling Engine.

INEXPENSIVE power for general purposes and electric lighting. The DuBois will operate at minimum fuel expense on Gas, Gasolene, Kerosene, Crude Oil, Alcohol or Distillate. Speed, Gas, Air and Electric Spark are adjustable while engine is running. New catalog just out.

Du Bois Iron Works,
805 Brady St., DuBois, Pa.

FLEMING-HARRISBURG ENGINES

have shown by many years of diversified service to be

PRACTICAL

Built along careful lines and of selected materials, with the idea of securing results in economical operation compatible with present day demands.

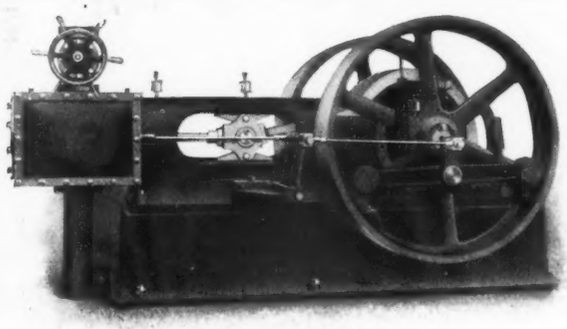
Many steam producing plants can be placed upon a highly economical basis by installing

THE ROSS MECHANICAL STOKER

Designed to realize in every-day practice the COMPLETE and SMOKELESS COMBUSTION of Soft Coal.

Write for our bulletins on these subjects.

HARRISBURG FOUNDRY and MACHINE WORKS
HARRISBURG, PA., U. S. A.



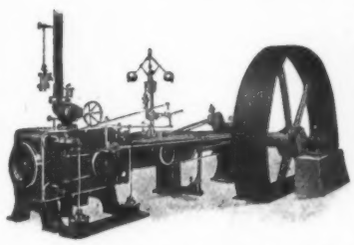
WE GUARANTEE BETTER REGULATION

with the McEWEN Engine than any other manufacturer now in the market. Send for our Bulletins and learn how we do it.

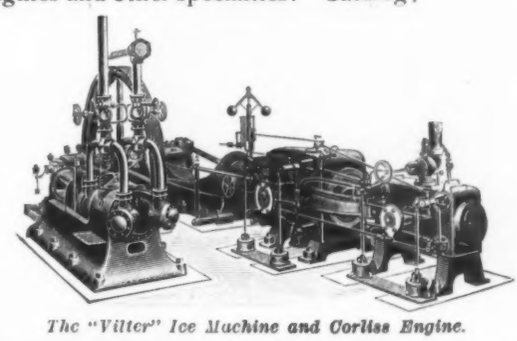
Ridgway Dynamo & Engine Co.,
RIDGWAY, PA.

Waterous Engine Works Co., Brantford, Canada.

We'll Install Complete Power Plants and Guarantee Fixed Results



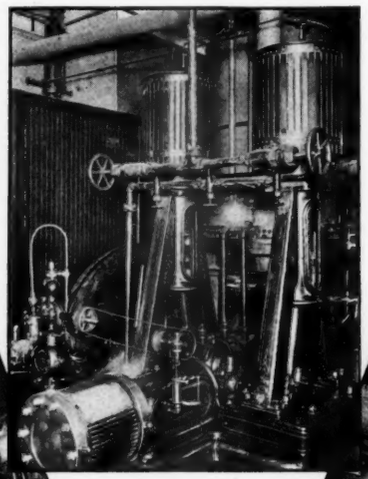
Nearly half a century ago we commenced to teach power users how to get the greatest returns for their money. Constant re-orders prove the high efficiency and sterling merit of our Corliss Engines and other specialties. Catalog?



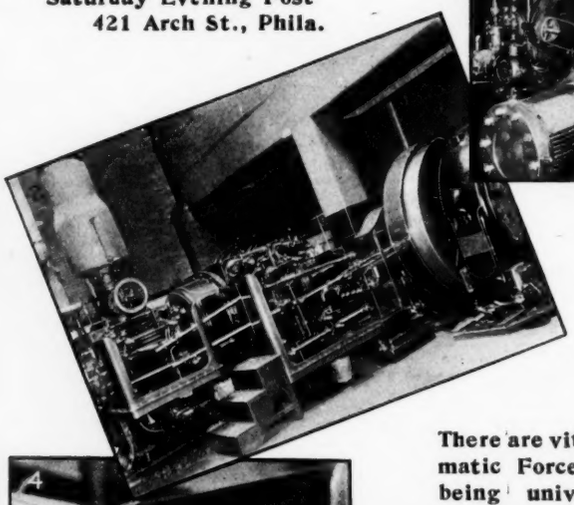
The "Vilter" Ice Machine and Corliss Engine.

The Vilter Mfg. Company,
854-894 CLINTON STREET,
Milwaukee, Wisconsin.

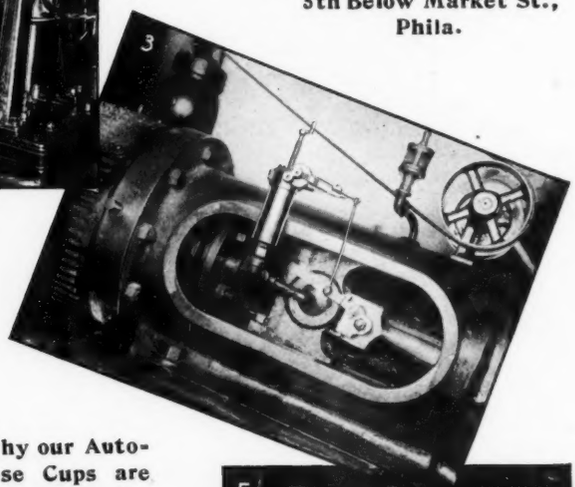
A Few Of Our Many Installations



2 and 4—Ladies Home Journal
Saturday Evening Post
421 Arch St., Phila.



1 and 3—PhiladelphiaBourse
5th Below Market St.,
Phila.



There are vital reasons why our Automatic Force Feed Grease Cups are being universally adopted by the largest and most successful power users in the country.

There are reasons why we claim superiority over all other methods of lubrication.

Here are a few

FIRST—Our Grease Cups work Automatically.

SECOND—They have a positive force feed; the bearings are cared for the instant the machinery is set in motion.

THIRD—They reduce the cost of lubrication from 50 to 75%; applying the grease only as needed.

FOURTH—They insure perfect lubrication in Bearings where heretofore it has been impossible to secure such results.

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Why suffer from oil soaked floors? Write for our circular and be welcomed into the fold of satisfied users.

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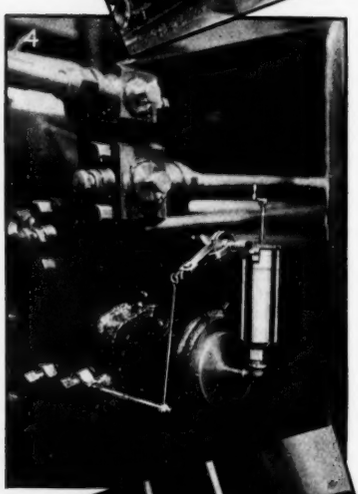

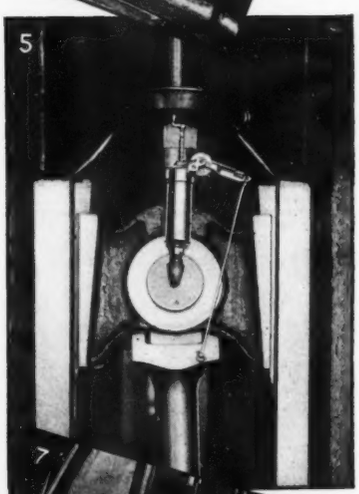

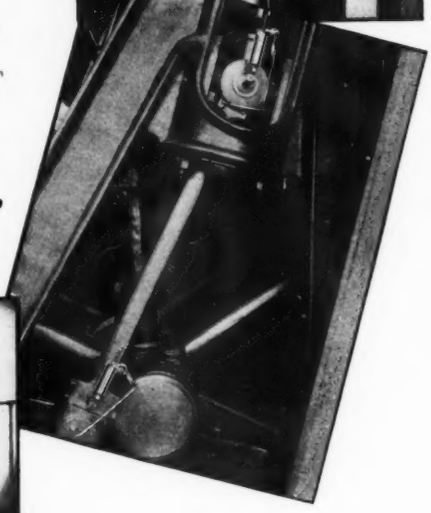

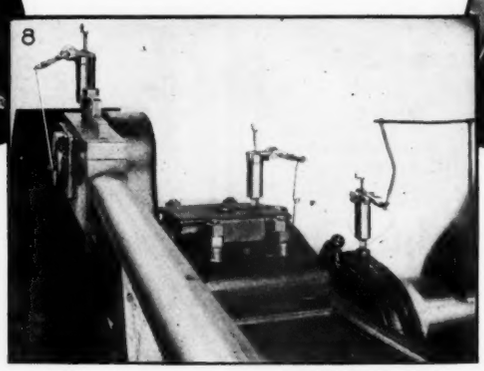

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Home of the Hill Publishing Company

Some More or Less Interesting Pictures Together with Information about the Office and Plant of the Publishers of POWER

As most of our readers know, the Hill Publishing Company is a descendant in direct line of the American Machinist Publishing Company, established in 1877, and has extended its field by the purchase of the Power Publishing Company, The Engineering and Mining Journal, Inc., The Johnson Publishing Company, and the Scientific Press, all publishers of engineering papers and books.

The concern occupies the three top floors of the Hallenbeck Building, on the corner of Park and Pearl streets.

Pearl street is laid out on the site of old Pearl creek of New Amsterdam days, and is as crooked as a rainbow handle. Starting east from Broadway below Bowling Green, it wanders in every direction of the compass all over the lower East Side and ends in Broadway three squares above the City Hall, a mile on Broadway from its start.

We thought a crooked street a good place for a straight business, and here we are.

It is the aim of the management to have everything that is useful and of good quality, but not very much for ornament.

Nothing is done by hand that can be better done by machinery.

System is used where it does not require more labor to keep the system than to do the work.

Something over two hundred people make their bread and butter here, and many of 'em also use pie.

There is approximately 11,000 square feet of floor space on each story. The top or tenth floor is occupied by the offices alone, the ninth by the composing room and press room and the eighth by the bindery and shipping room.

The plan on another page will give some idea of the general arrangement of the main office. It can not, of course, show the location of many desks in the editorial rooms. There is plenty of light from windows on all four sides and two large skylights.

We hardly think it necessary to go into any extended description of the plant and offices; the pictures show things better than written words and in a language all can understand.

Fig. 1 is a view of the building from the corner of Pearl and Centre streets.

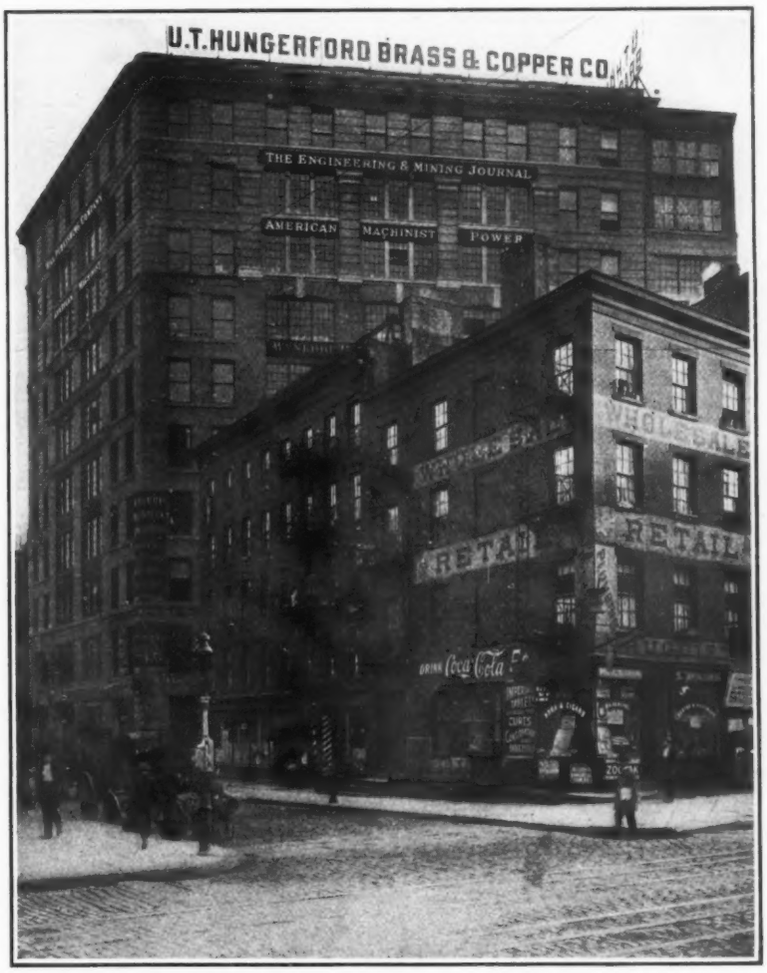


FIG. 1. FIVE HUNDRED AND FIVE PEARL STREET, FROM THE CORNER OF PEARL AND CENTRE

Fig. 2 is a view taken from behind the counter at the office entrance. On the extreme left are the make-up desks, the door beyond going into the locker room. The eagle is over the door of a large fireproof vault, and beyond against the back walls can be seen the huge letter file, holding over half a million letters. Immediately in front is the mailing department with copying machines and power letter sealer. In the center is the waiting room formed by sectional book cases, those facing in being filled with new books for sale, those facing out containing the editorial reference library. Against the wall to the right are four dictating booths containing phonographs. All dictation in this office is to phonographs, no stenographers being employed.

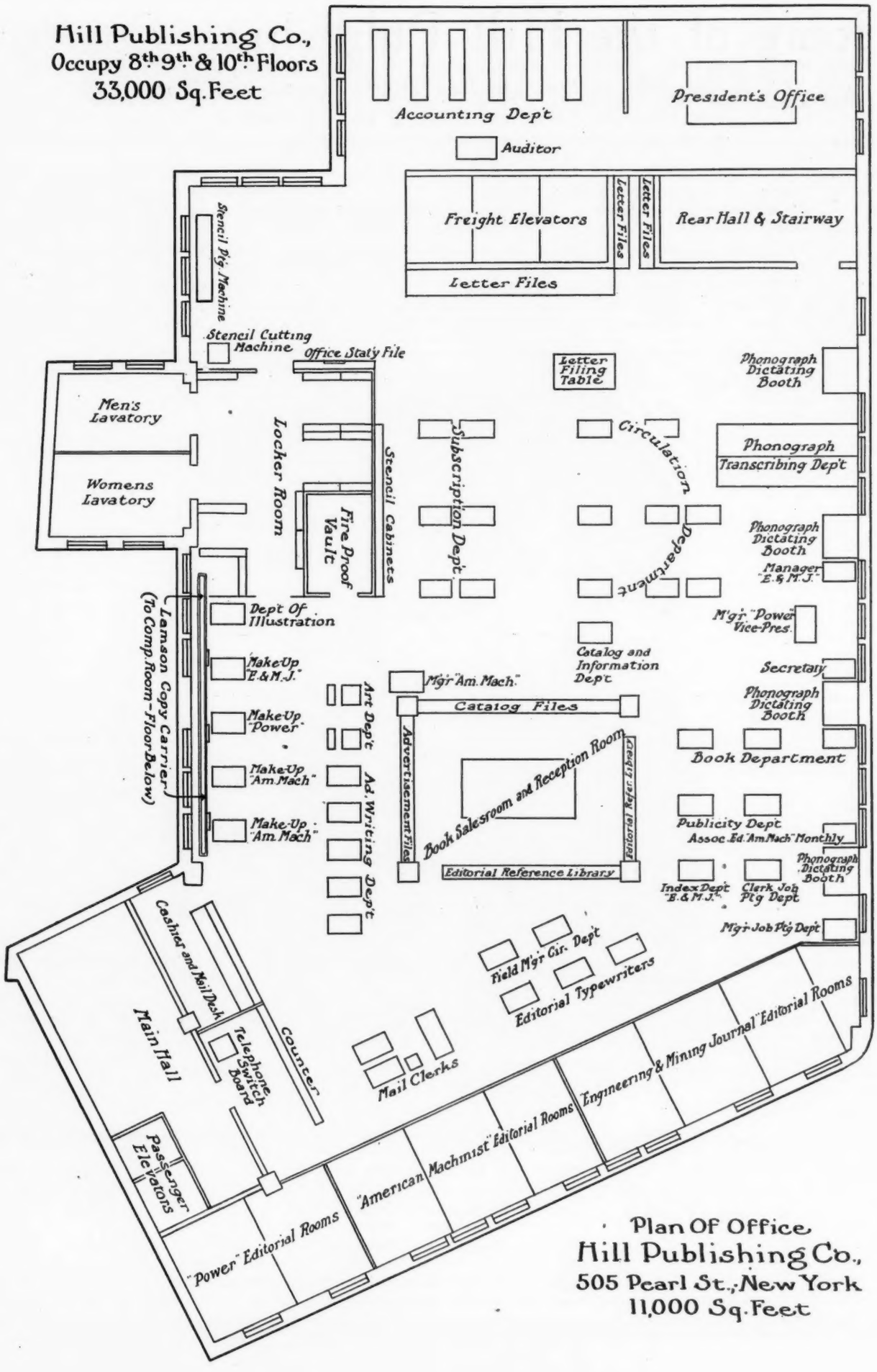
Fig. 3 is a view taken from near the back stair door, looking toward the editorial offices. In the left foreground are the typewriter desks, where all letters are written from dictated records. On the right is the subscription department; the cabinets against the wall contain the stencils for all the mailing lists.

Fig. 4. Our vice-president is the active office manager and from his desk can be seen every other desk in the main office. This view, looking to the right, shows in the far corner a bit of the bookkeeping department.

Fig. 5. The other view, looking to the left, from same point. Editorial rooms in front; book department to right. Away against the light just over the fire extinguisher near the post can be seen the mechanism of the endless conveyer that carries copy, proof, cuts, etc., from the make-up desks to the superintendent's desk on the floor below.

And now let us go down and see the wheels go around. Here is a clean printing office and bindery, where the floor is scrubbed anon and the windows clean, where there is light and good air. All the machinery on these two floors is enameled white and wiped off twice in a while. Every machine has its own electric motor and there is no shafting or belting overhead.

Fig. 6 shows the delivery end of the row of presses, first seen when entering the room by the rear door. Of course half of this floor is taken up by trucks and paper storage, sorts caster, melting pots, etc., not shown.



Plan Of Office
Hill Publishing Co.,
505 Pearl St., New York
11,000 Sq. Feet

FIG. 2. VIEW FROM FRONT DOOR LOOKING DIAGONALLY ACROSS THE OFFICE, SHOWING RECEPTION ROOM IN CENTER

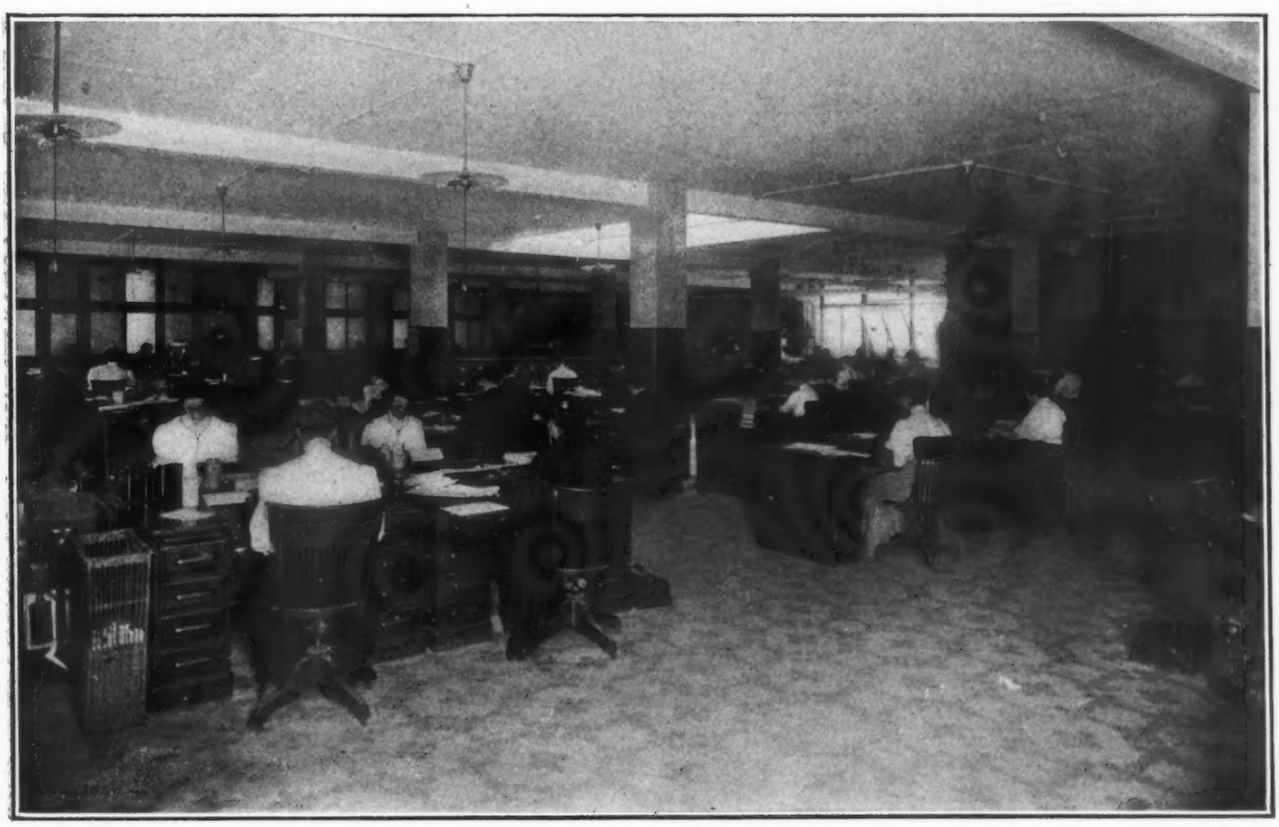


FIG. 3 FROM THE REAR OF OFFICE LOOKING TOWARD EDITORIAL ROOMS AND THE MAIN ENTRANCE, CENTER OF PICTURE

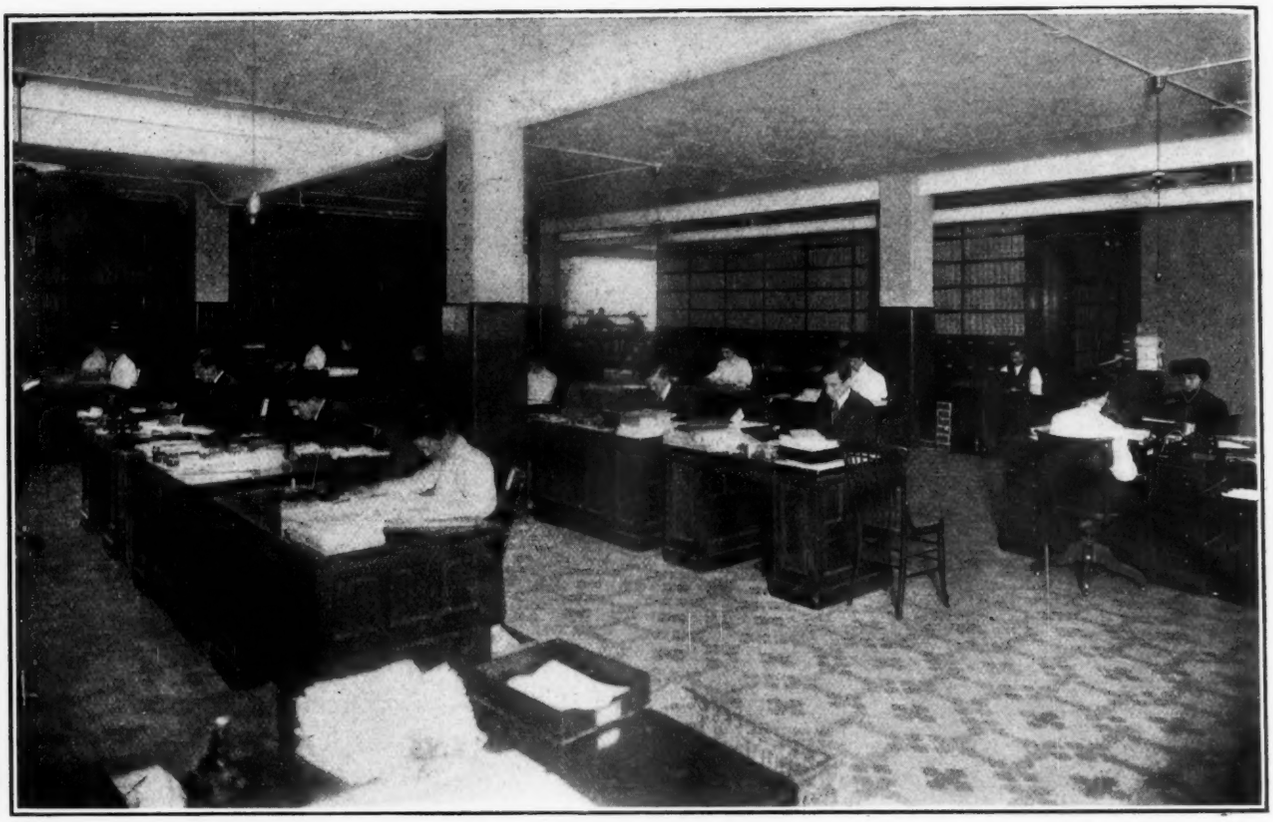


FIG. 4. FROM THE VICE-PRESIDENT'S DESK, LOOKING RIGHT. BOOKKEEPERS IN FAR CORNER, LETTER FILES ON RICHT

FIG. 5. FROM VICE-PRESIDENT'S DESK, LOOKING LEFT, SHOWING BOOK DEPARTMENT AND EDITORIAL ASSISTANTS

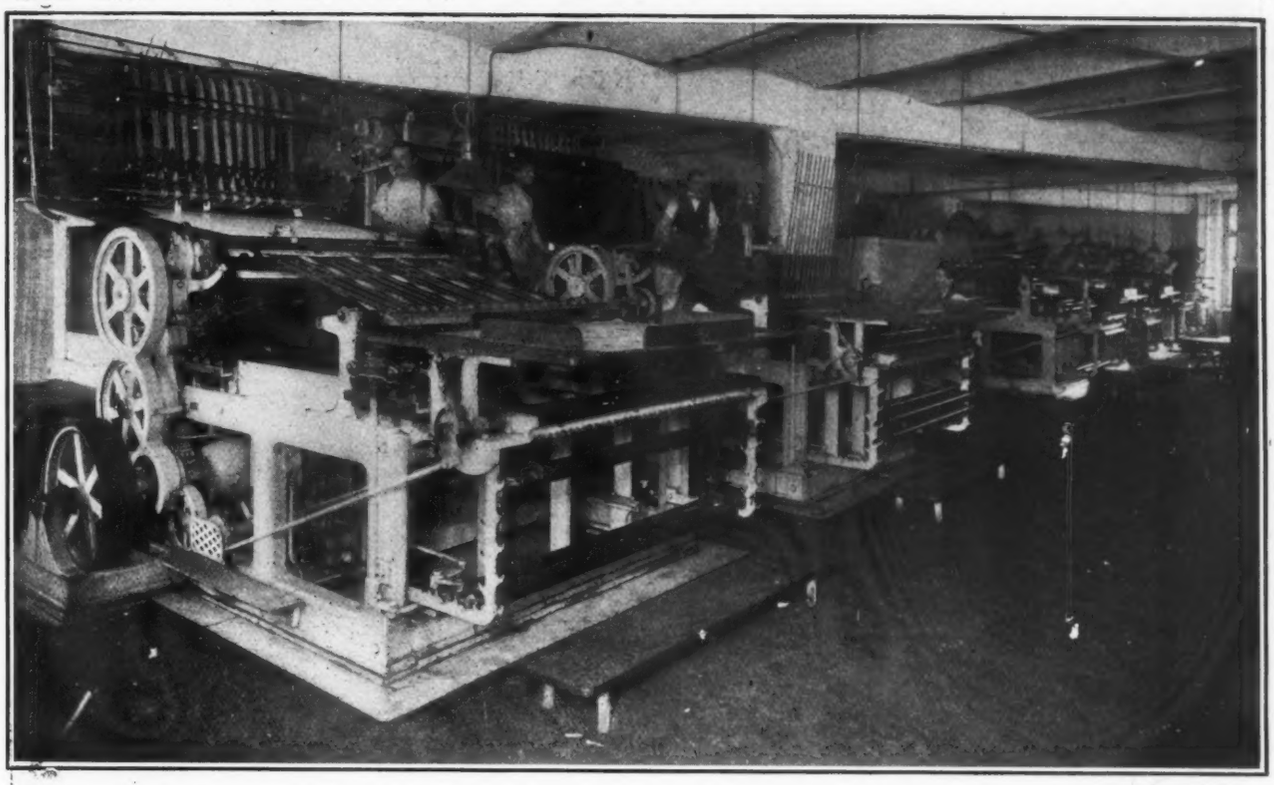


FIG. 6 DELIVERY END OF ONE OF THE ROWS OF PRESSES, SEEN FROM THE REAR ENTRANCE

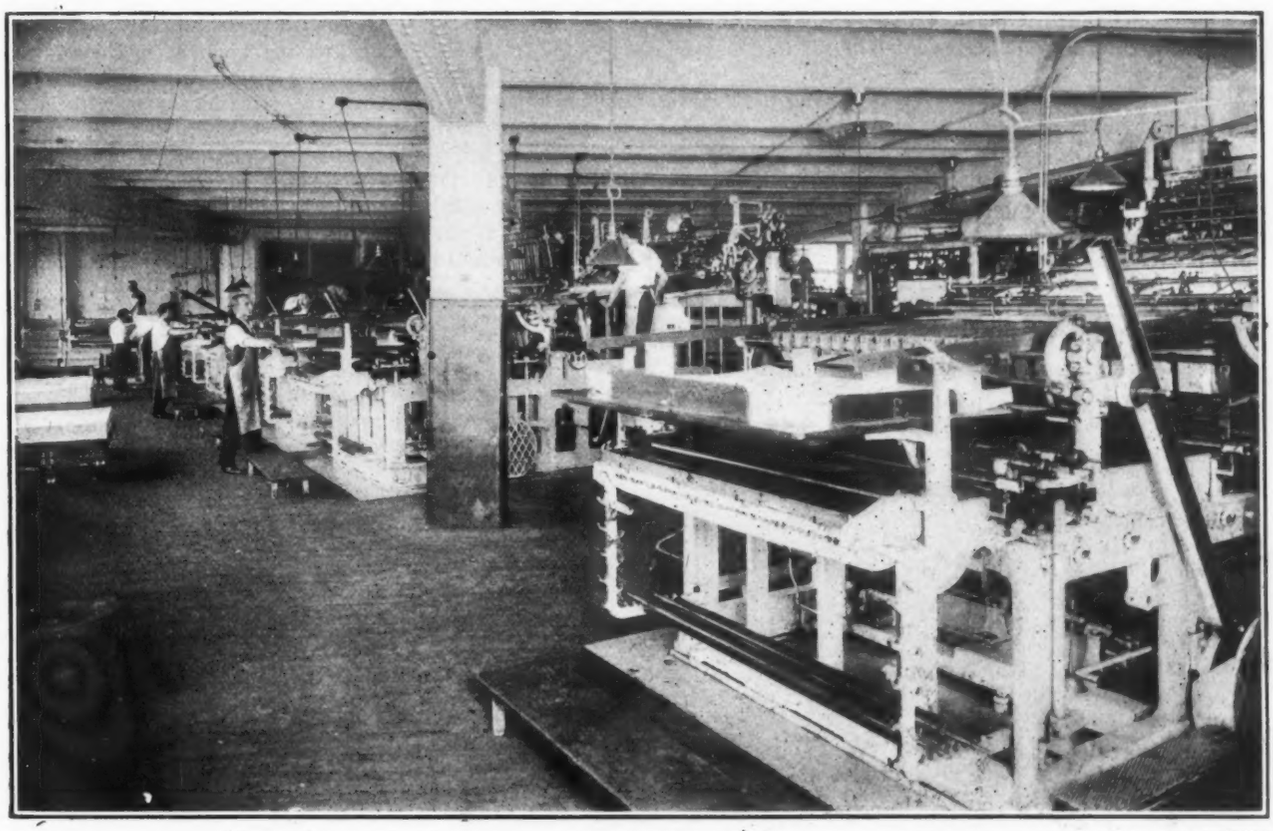


FIG. 7 THE OTHER ROW OF PRESSES, DELIVERY END TOWARD PEARL STREET

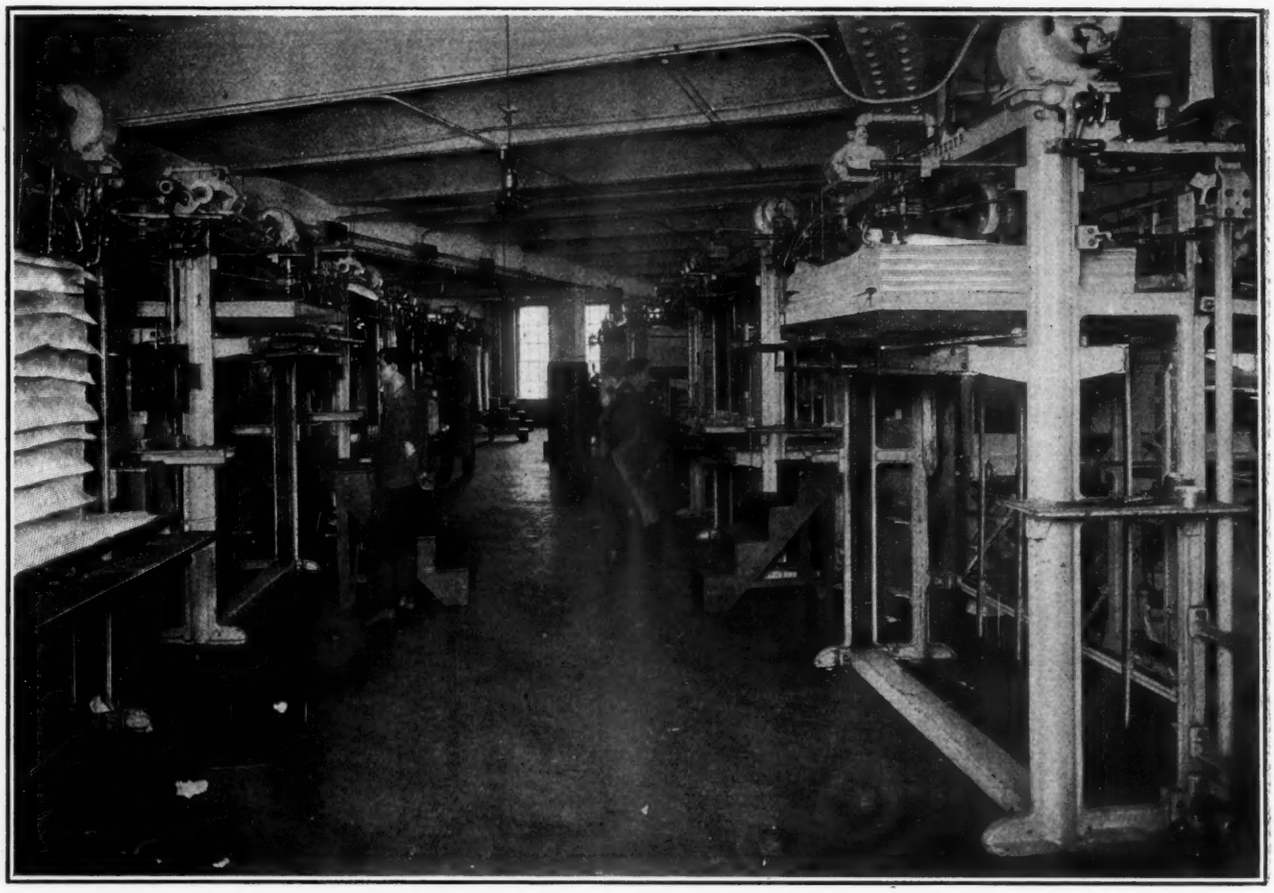


FIG. 8. THE ALLEY BETWEEN THE PRESSES, SHOWING THE AUTOMATIC FEEDERS

Fig. 7 shows the row of presses and feeders facing the windows on the Pearl street side. In the far end of the alley can be seen a press used only for printing covers.

Fig. 8 shows the alley between the two rows of presses and shows the self-feeders. The paper is piled straight on a sub-truck, a flat maple platform on small wheels, and this on a big truck. When the attendant wants to put the paper on any feeder for any run, he pushes sub-truck and all onto the feed table and the machine does the rest. The usual truck loads of paper have been removed to show the machines.

Fig. 9 shows the composing room, where nothing but advertising is set. The equipment in this room is so arranged that any drawer of type may be reached without disturbing the man working at the case. All ads when set are carried toward destination when finished and nothing has to be carried backward.

FIG. 9. ADVERTISING COMPOSING ROOM

Fig. 10, the Linotype machines, where the reading matter is set. As everyone knows, these machines make their own type as they go along, distribute the last line while the new one is being set and otherwise act so intelligently that they ought to be allowed to vote.

Fig. 11 shows a corner of the job room on the eighth floor, where nice printing is done.

Fig. 12, in the same department, shows some platen presses, etc.

Fig. 13 shows the self-feeding folding machines on the eighth floor. These machines take the product of two presses, 32 pages, and deliver it in two signatures of 16 pages each, folded. From these machines the folded sheets are put through presses and tied up into bundles and piled on the floor opposite their proper place on the gathering machine.

Fig. 14 shows the line of automatic binding machinery and is the only arrangement of its kind that we know of. On the left the long machine is the gatherer. It is fed from this side with piles of each section that goes to make up a paper, be it two sections or twenty-two. This machine gathers the books, jogs them straight and carries them to the stitcher. Now this machine will find all signatures that are wrong, a sheet of

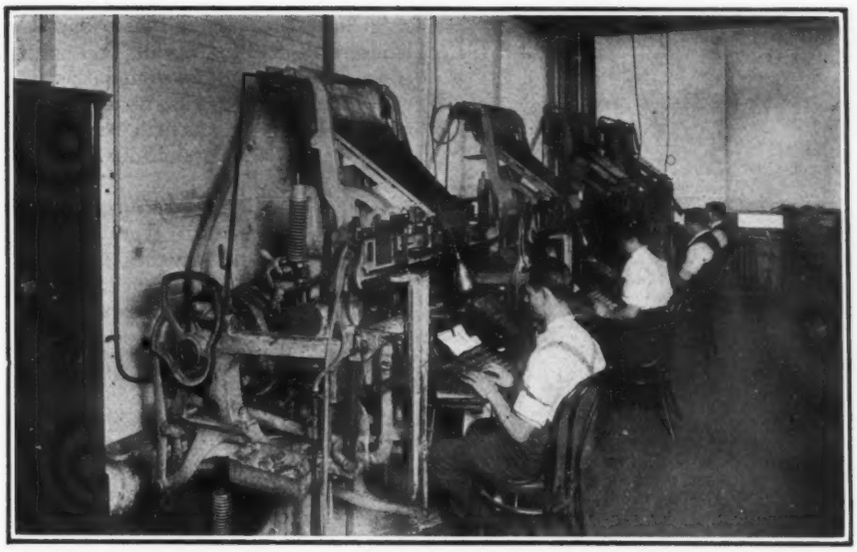


FIG. 10. LINOTYPE MACHINES

paper too thick or too thin or upside down, or if it misses one or takes two, it will stop and put up a signal telling where the trouble is. A boy, without moving from his tracks, takes the stitched books from the delivery packer and puts them on the table between the stitcher and the covering machine. This machine feeds in the books in one place and the covers in another and glues them on. From the delivery of the coverer the books go to the feed table of the automatic trimmer, where, taking three cuts at once, the books are trimmed to the proper size and are delivered directly upon the mailing table, where they are wrapped and put into the mail bags, without a false move of any kind.

The average weight of our publications is upward of 90,000 pounds per week, and every precaution is taken against unnecessary handling of this great weight.

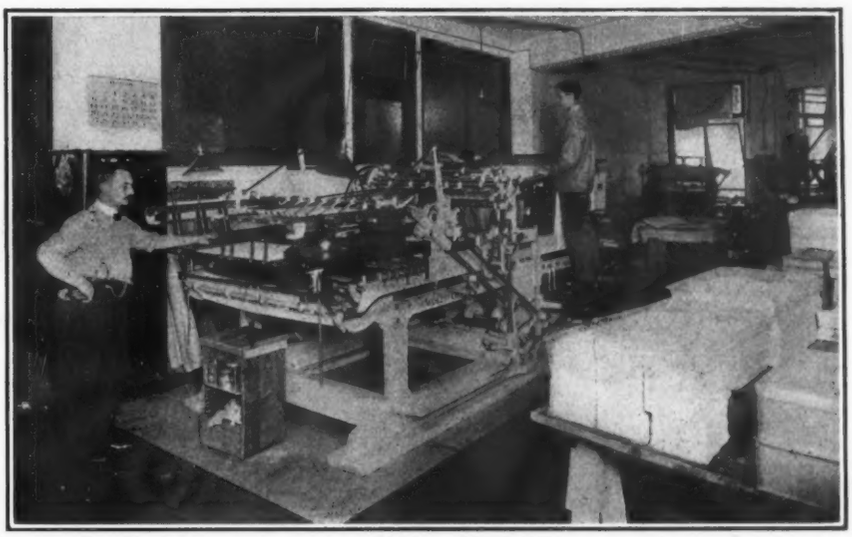


FIG. 11. A "PONY" IN THE JOB ROOM

FIG. 12. ANOTHER CORNER IN JOB ROOM

Fig. 15 shows the shipping room. On the right can be seen the open stock of back numbers and stationery. In the far corner is a grated door leading into a room devoted to the care of the stock of bound books.

The office of the Hill Publishing Company is open and a welcome extended to all our readers and advertisers when they come to New York. We are always glad when any of them have their mail addressed in our care and make the office their headquarters, and all are invited to do so.

Five hundred and five Pearl street will not be so hard to find after Father Knickerbocker gets through with the little improvements now going on right at the corner of our building. Something overy thirty millions will be spent there.

The buildings in the foreground of Fig. 1 have all been condemned and will come down. All the buildings between 505 and the Brooklyn bridge on the right of Fig. 1 have been condemned, and two-thirds of them have been torn down and excavating is going on now.

Here will be the new terminals of the Brooklyn bridge, of the subways connecting the three bridges, of the Third avenue elevated road and a great transfer station of the present subway and surface lines.

A point where centers the greatest activity and the greatest number of people in Greater New York. Our building will face these terminals, which touch City Hall park on one side, the great newspaper offices on the other, while to the left, conveniently located, is the Criminal Courts and the City Prison, a block or two behind us is Mott, the Bowery and the Chinese quarter—we've got everything within walking distance; come in and see us.

This then is the end of an attempt to

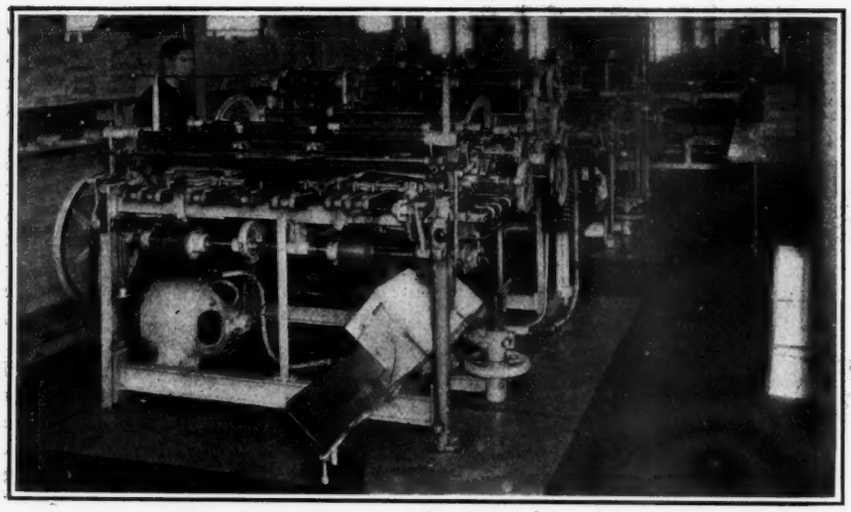


FIG. 13. LINE OF AUTOMATICALLY-FED FOLDING MACHINES

useful little books are given to operative engineers all over the world.

The *American Machinist* indulges in a special number only once in five years—the last being its thirtieth anniversary number issued on November 7—and containing 530 pages.

The Engineering and Mining Journal issues a special number every quarter—one devoted to the statistics of mining, giving the output of the year for the whole world, in January; two devoted to the mines of Mexico, in April and July; and one devoted to the coal mines of America, in October.

Any and all of these special issues would be most excellent mediums to exploit products suitable for these fields of engineering, because they go not only to all the regular subscribers, but to the entire possible list as well.

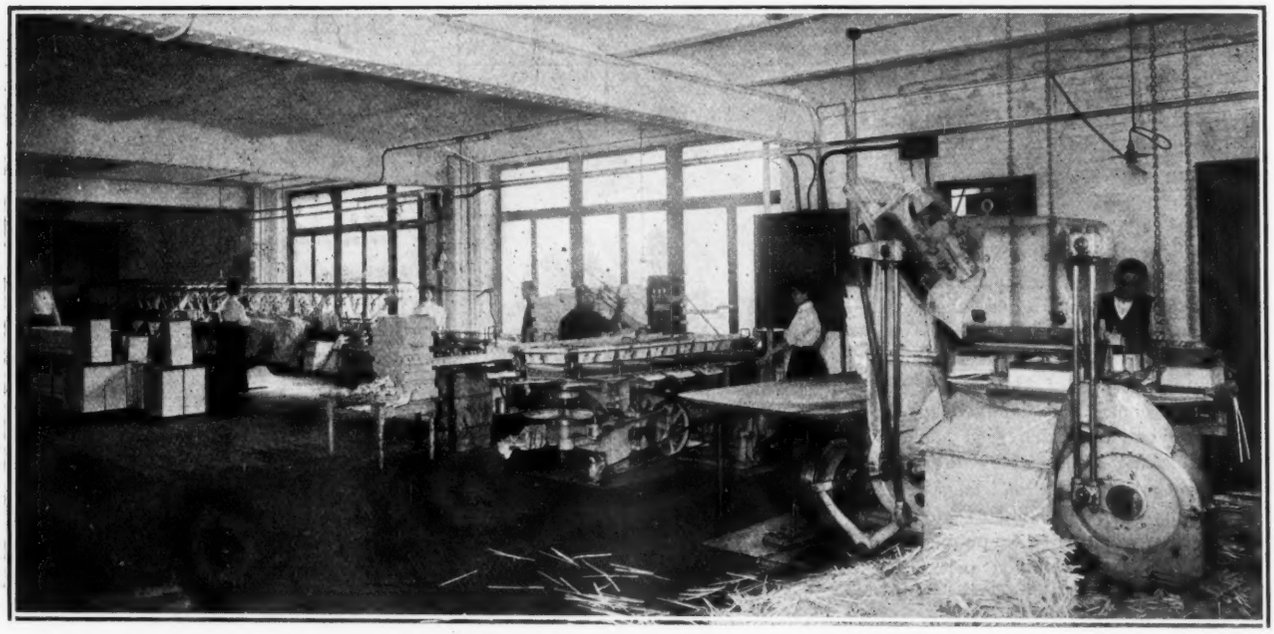


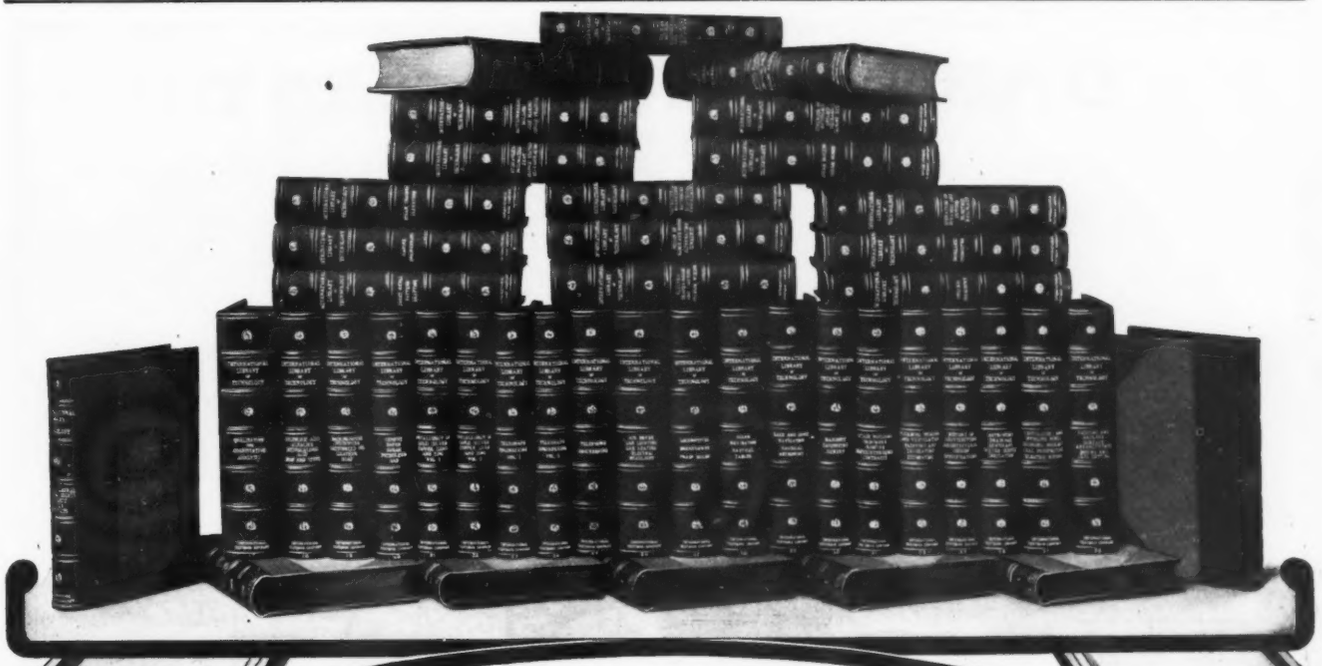
FIG. 14. THE LINE OF AUTOMATICS. GATHERING, STITCHING, COVERING AND TRIMMING A CONTINUOUS STREAM OF PAPERS

give you a little idea of the facilities and equipment of the House of Hill, devoted to the publishing of three good engineering papers and sundry books designed to be of use to men who do things.

Notable Special Numbers of Our Publications

POWER issues a handsome special edition every December, and from the Advertising Directory in that number issues a pocket-book, giving names and addresses of the makers of all engine and power-house supplies—20,000 of these

FIG. 15. SHIPPING ROOM, EIGHTH FLOOR



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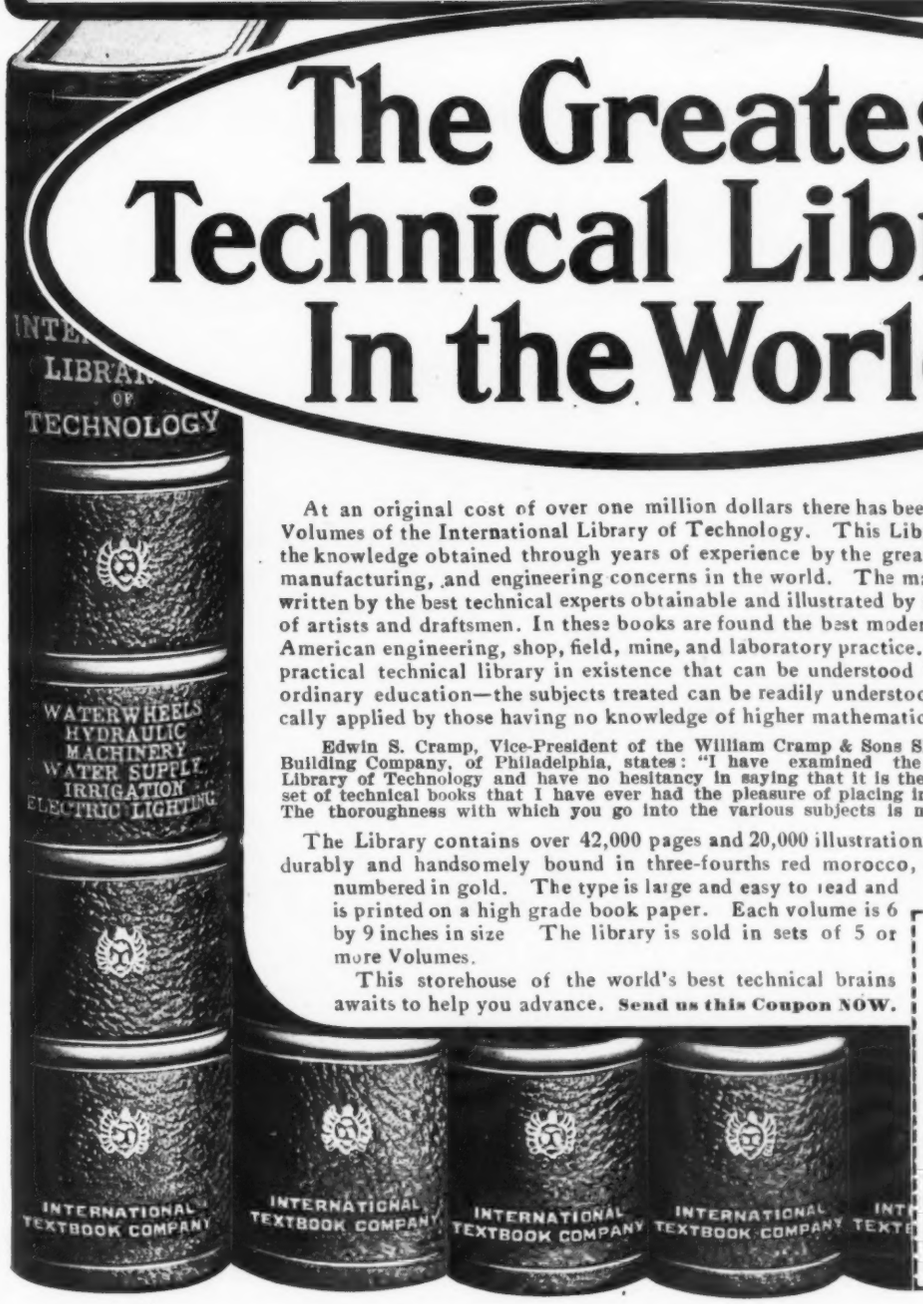

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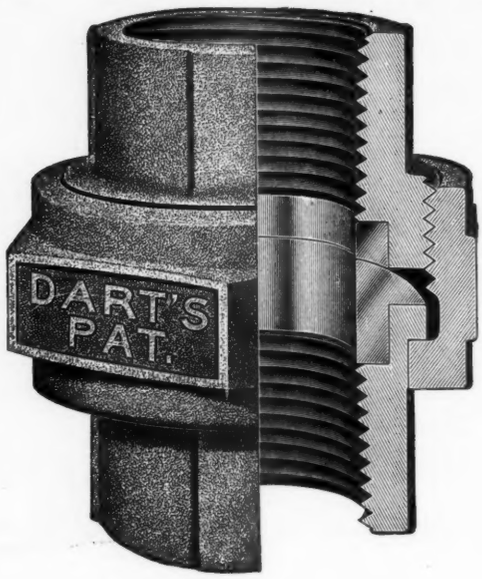

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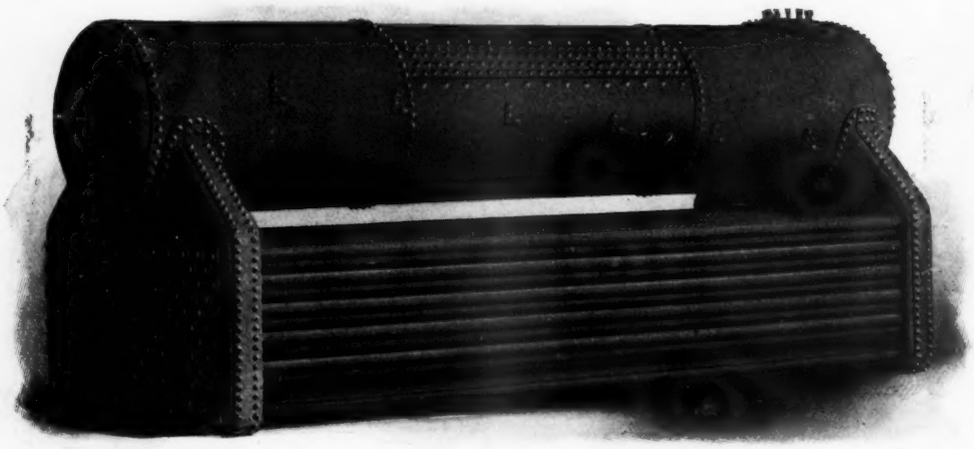

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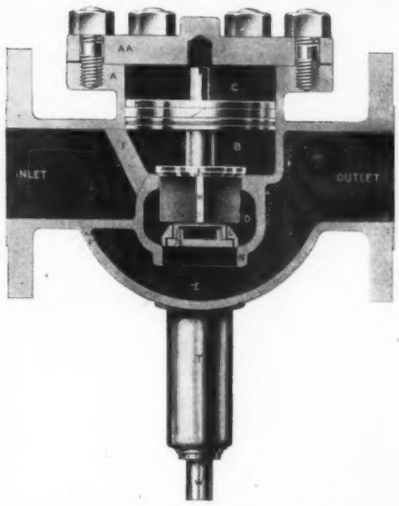
FOR STEAM



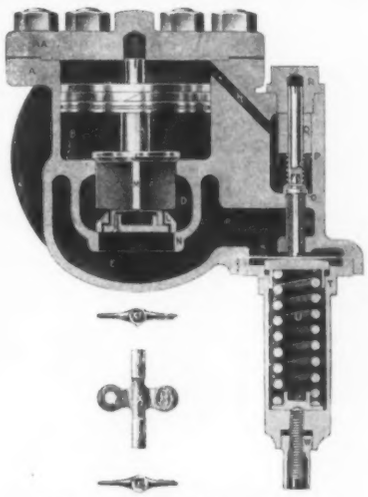
Longitudinal Section of Valve.

¶ Not only reduces the *initial* pressure, but regulates the *service* pressure.

¶ Cutting of the main valve (J) is *absolutely prevented* by the supplementary piston (L) which seats *in advance* of (J), thus checking the velocity of the steam passing through the main valve at the time of closing.

¶ Foreign matter cannot reach the controlling valve (G) because the only access to it is through a very small hole drilled in the main piston (K).

¶ These points, combined with the simplicity and accessibility of the parts, *assure continuous satisfactory service.*



Transverse Section of Valve.

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13 x 20 Williams, left-hand, double valve, automatic engine
14 x 20 Atlas, right hand, automatic engine.
8 x 8 Vim, center-crank, auto. engine on sub-base
8 x 9 N. Y. Safety, center-crank, auto. engine.
11¼ x 14 Woodbury, center-crank, auto. eng.
15½ x 15 Armington & Sims, center-crank, automatic engine on sub-base.
9½ x 12 Phoenix, center-crank, auto. engine.
7 x 10 Erie City Iron Works, right-hand, throttling governor engine.
10 x 16 Atlas, right-hand, throt. gov. engine.
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7 x 9 New York Safety, center-crank, vert. throttling governor engine on sub-base.
Vertical engines, all sizes and makes.
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12 x 6 x 10 Worthington Duplex Pump.
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No. 2, No. 3, No. 4 Morris Centrifugal Pumps.
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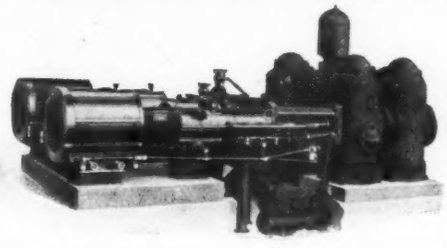

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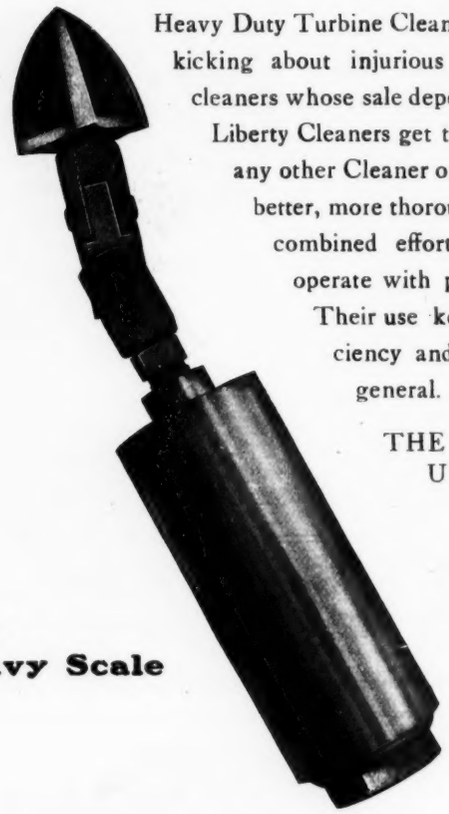

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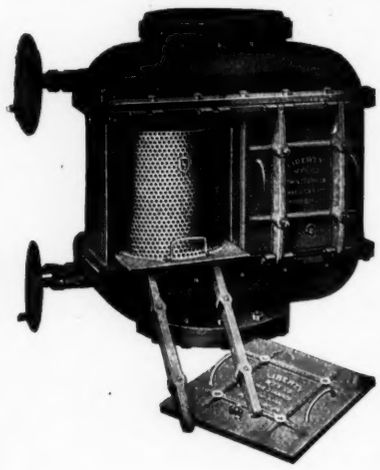

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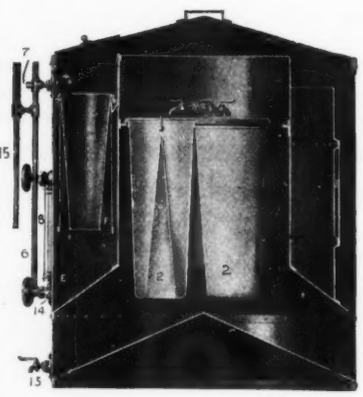

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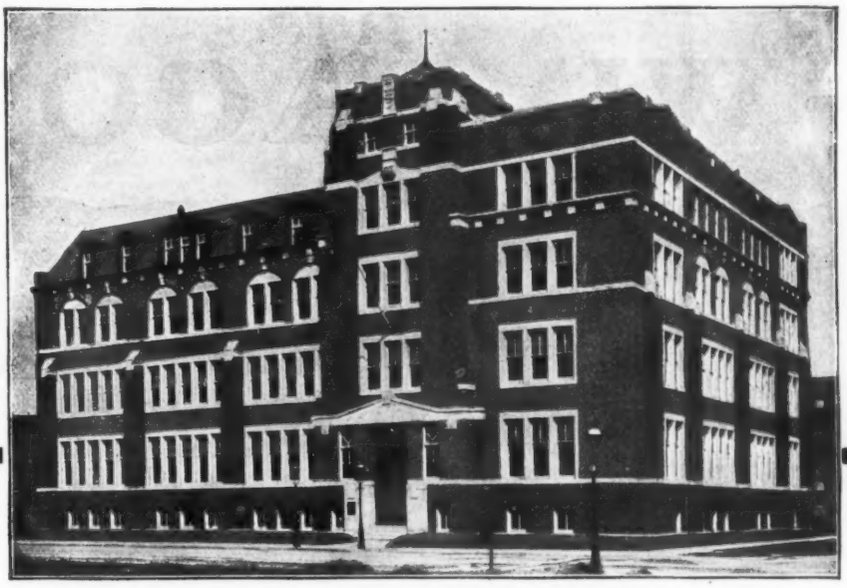

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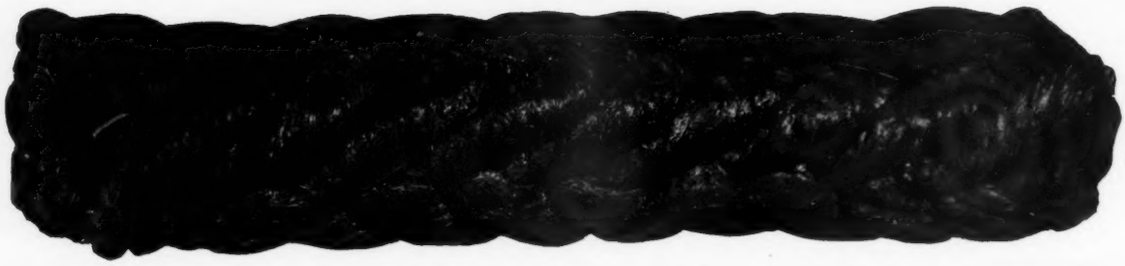

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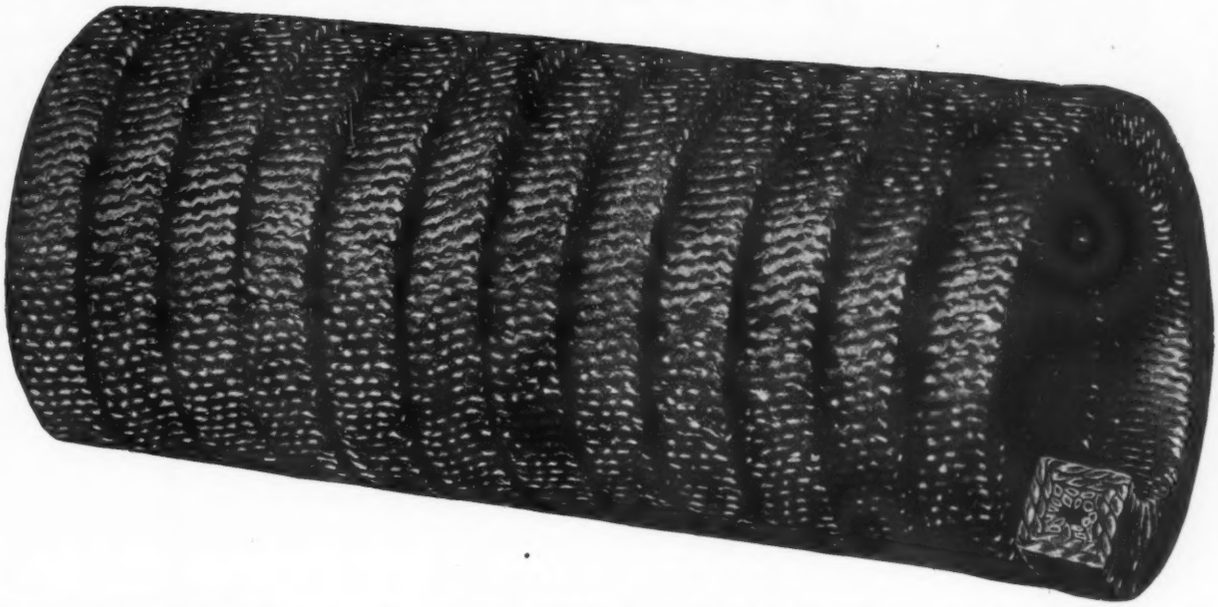

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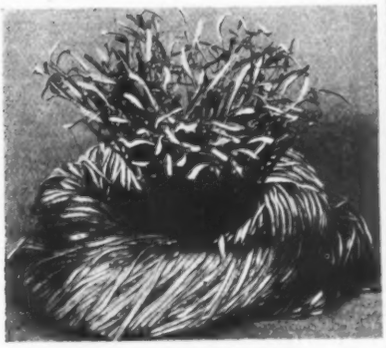

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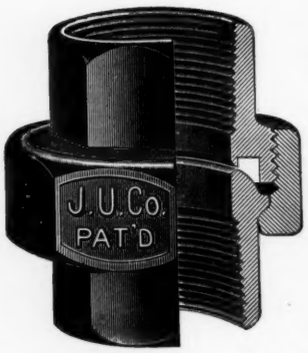

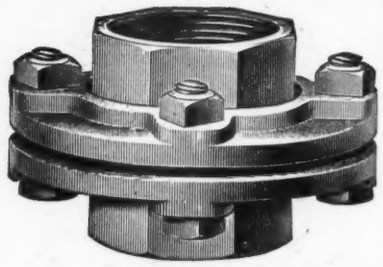

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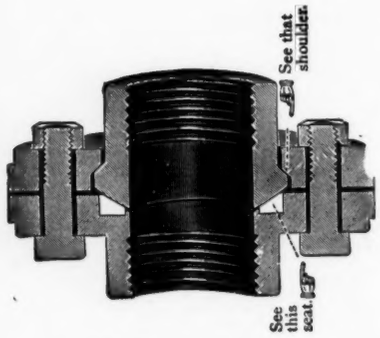

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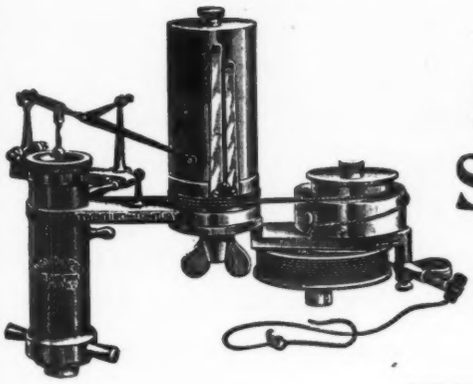

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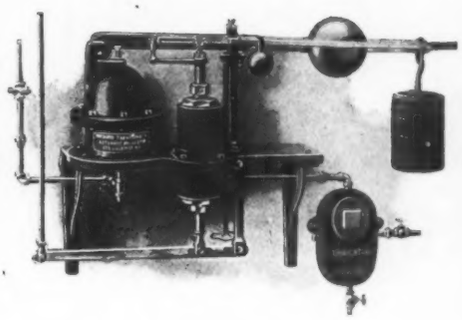

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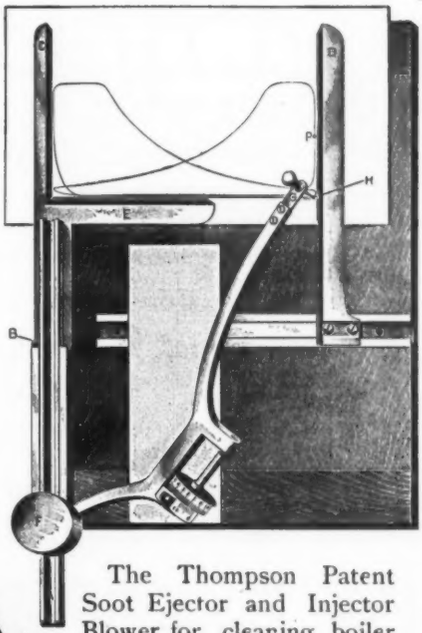

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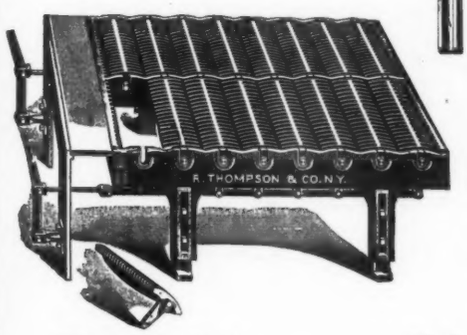

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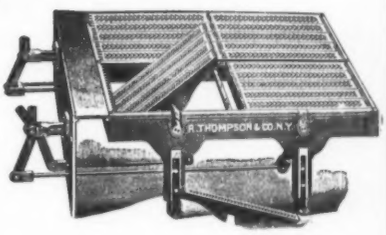

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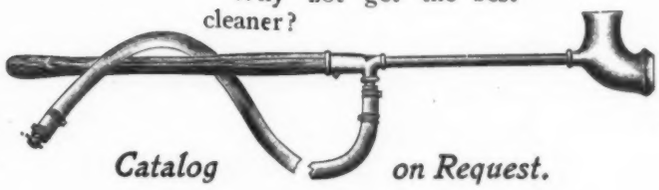

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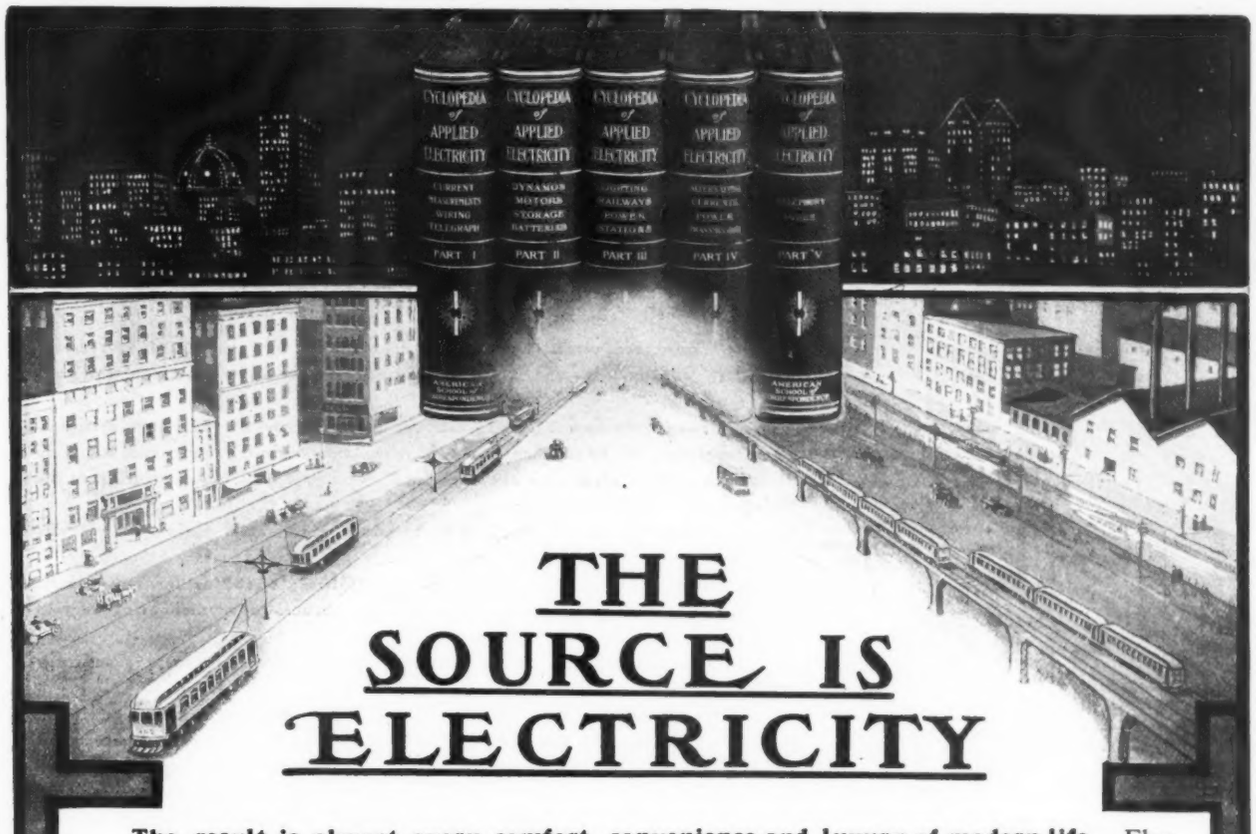

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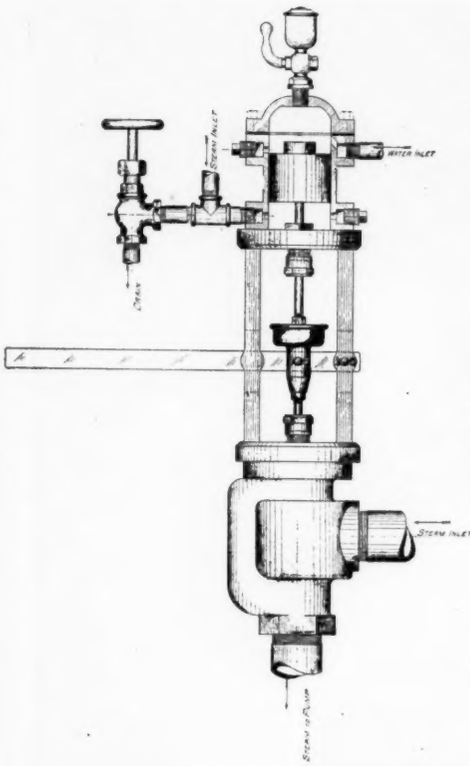

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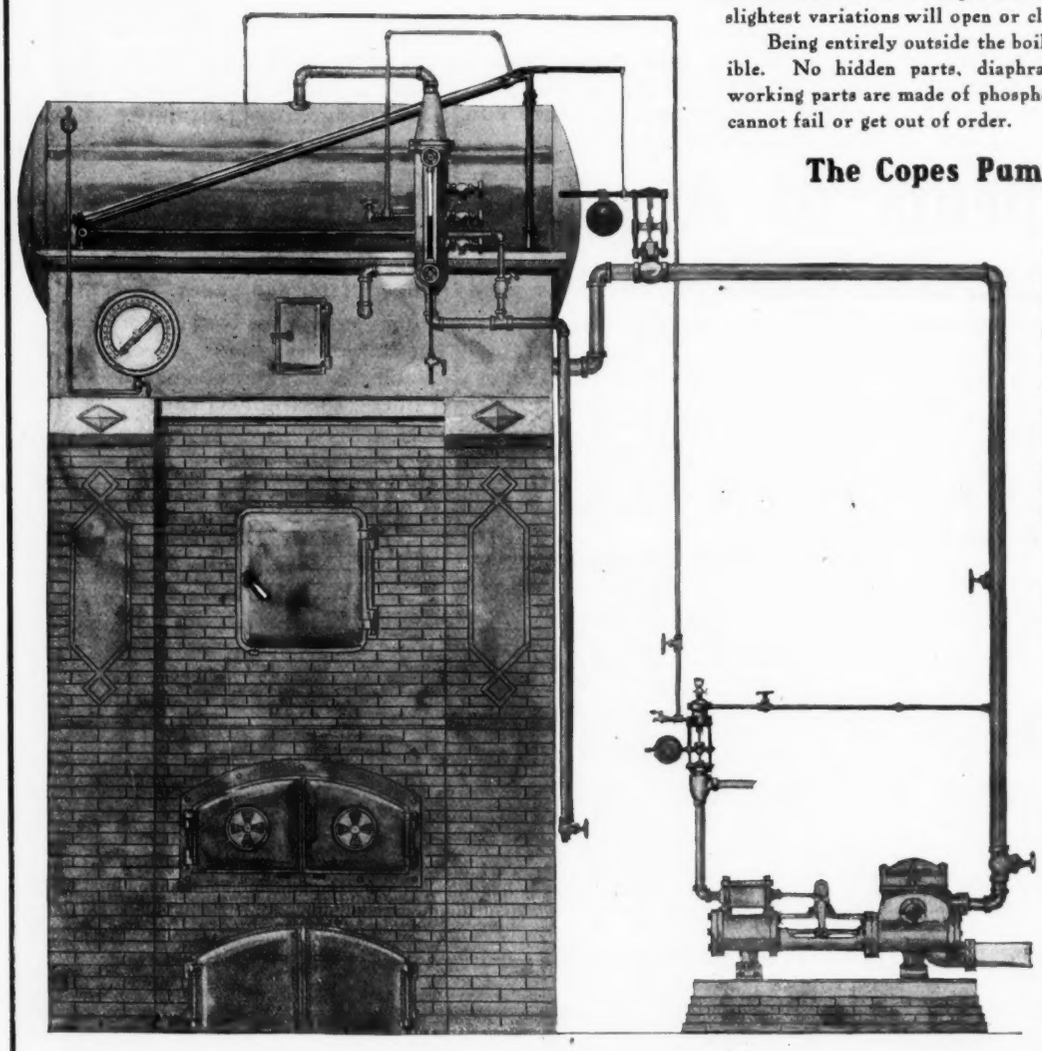
The Copes Automatic Boiler Feed Regulator maintains a uniform water level, which **cannot vary** a **quarter of an inch** from one year's end to the other. The Copes is extremely sensitive and the slightest variations will open or close the valve.

Being entirely outside the boiler; it is always accessible. No hidden parts, diaphragms of floats, and all working parts are made of phosphor-bronze, nickeled. It cannot fail or get out of order.



The Copes Pump Governor

For boiler feed pumps—elevator pressure tank pumps — fire pumps, wherever high grade governors are required, the Copes Pump Governor is absolutely necessary. Approved by Board of Supervising Inspectors United States Steamboat Inspection Service, for use on steam vessels.

The Copes is sent on 30 days' free trial. Shall we send you one?

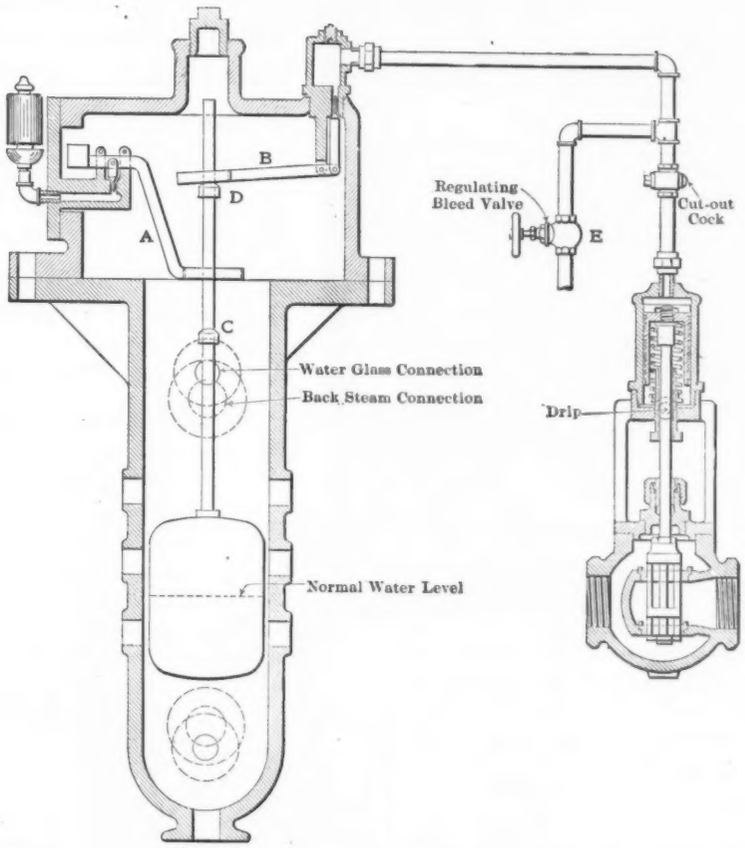
WRITE FOR CATALOGUE

The American Boiler Economy Company

North American Bldg., Philadelphia, Pa.

BOSTON OFFICE,
313 OLIVER BUILDING,
BOSTON, MASS.

The Money Value Of A Perfect Water Level



No Extra Fuel To Heat High Water

No Boiler Explosions Resulting from Low Water

The Gould Feed Water Regulator

A simple, positive and thoroughly effective regulator which admits the feed water in exact proportion to evaporation.

By adjusting the bleed valve you can place the level where you like and the regulator will permit absolutely no variation.

The controlling valve, unlike single seated valves, cannot be forced open by back pressure and a spring prevents sticking to its seat.

Alarm valve and operating valve in column removed and replaced without disconnecting upper part of water column. This accessible feature not embodied in other regulators.

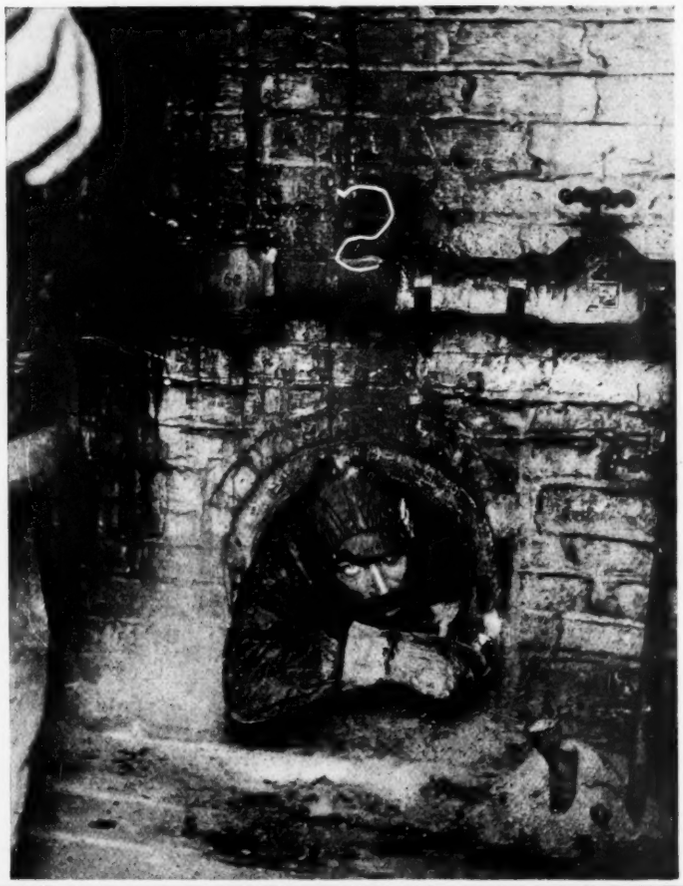
A perfect water level means a minimum consumption of fuel and no boiler explosion, there's money in it. MAY WE SEND YOU THE BOOKLET?

THE SAFETY EQUIPMENT MFG. COMPANY

POWER PLANT SPECIALTIES

Fisher Building - - - Chicago, Illinois

Standard Engineering Company, Licensees—Dominion of Canada, Toronto, Ontario.
SALES AGENTS—Boston, Mass., Walter G. Ruggles Company, 54 High St. New York City, H. M. Underwood, 3 Park Row.



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Capital,	Assets,	Surplus,
$1,000,000.	$7,865,185.55.	$1,622,129.12.

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The Company aims to prevent explosions by careful inspections by competent men at regular intervals. If in spite of all precautions an explosion does occur, indemnity is provided for—1st, the direct loss of property; 2nd, damages for property of others destroyed; and 3rd, damages for personal injuries. Our inspectors thoroughly "hammer-test" the boilers inside and out. Write to us for rates and particulars.

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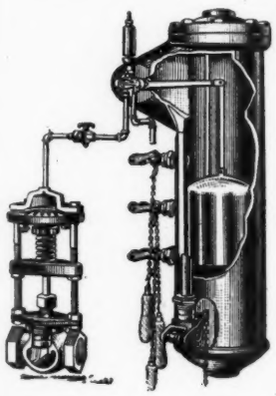

Economy and Safety

go hand in hand wherever *Berry Regulators* are used, because of a close regulation of the water level.

Ask for the Catalog.

The Berry Engineering Company,
Chester, Pa.

Watson Steam Pump Governor

For maintaining an even water pressure. Should be used on all steam pumps where a fixed discharge pressure is desired. Designed right and made right, it is automatic and reliable. Send for catalogue.

Watson & McDaniel Co.,
Philadelphia, Pa.

Strangely Simple when compared with others

THE FISHER GOVERNOR

Maintains perfectly the pressure regulation for which it is set and you can set it where you like, with the greatest ease.

Circular?

FISHER GOVERNOR CO.,
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If you'll state the size of your steam line we'll send you any Separator you may select, let you try it for thirty days, and if results are not entirely satisfactory you may return it at our expense of transportation both ways.

A PAGE OF AUSTIN STEAM AND OIL SEPARATORS

We will give a written guarantee that any live steam Separator we ship will extract all moisture from the steam current, and that any Oil Separator of our make will eliminate all oil and impurities from exhaust steam, rendering its condensation distilled water.

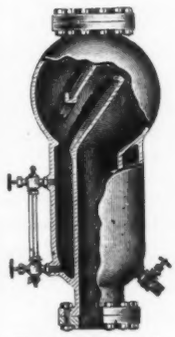


Fig. "M" Vertical Iron Receiver Separator.

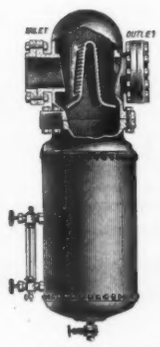


Fig. "L" Horizontal Cast Head, with large steel shell Receiver.

Fig. "S" Horizontal Special Oil Separator.

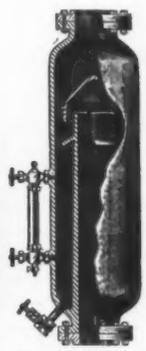


Fig. "H" Vertical Iron Receiver Separator.

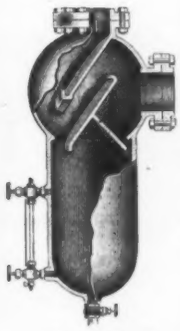


Fig. "N" Angle Iron Receiver Separator.

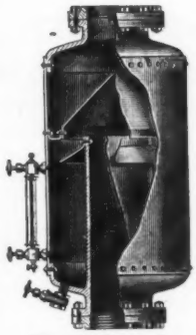


Fig. "O" Vertical with large steel shell Receiver or Accumulator

WE have been making Steam and Oil Separators for nearly twenty years. Our machines are standard the world over. We carry a stock of "Regular" types ready for immediate shipment. We maintain an Engineering Department expert in the design and construction of special separators for special purposes. We invite correspondence and assure you our prompt and careful attention.

We issue a catalog replete with information governing the use of steam and oil separators, which will be mailed on receipt of request. Send for it.

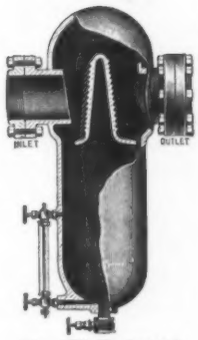
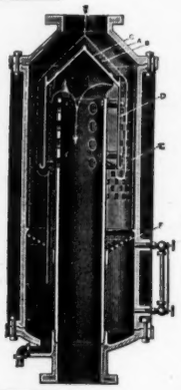


Fig. "E" Horizontal with Iron Receiver. Great Capacity.

AUSTIN SEPARATOR CO.

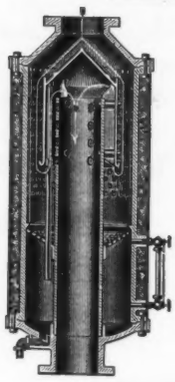
DETROIT, MICHIGAN. 57 WOODBRIDGE ST.

Why Sweet's Separator Is The Best Investment.



It has *ample separating surface* for *all conditions—space* for *steam storage* and room for *quite a little water*. It is because of these strong points that the *Sweet Separator* surpasses all others.

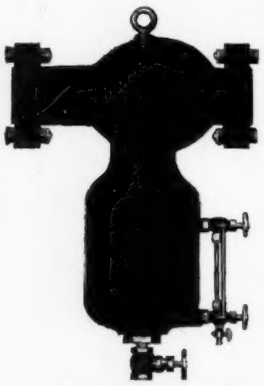
The majority of separators take *some* water out of steam, but where's the Separator that removes all but ½ of 1 per cent. *all the time*—like Sweet's? Our Separator holds all the water that's coming, while others are not large enough. You can't squeeze a gallon of water into a two-quart can. See the point?



Can't you figure out why *Sweet's* would be the *best investment* for *you? We* can prove our claims, if you'll allow us an opportunity.

ASK FOR THE CATALOG.

DIRECT SEPARATOR CO., 712 GEDDES STREET, SYRACUSE, N. Y.



"SWARTWOUT" VERTICAL and HORIZONTAL SEPARATORS

Operate upon the principle of CENTRIFUGAL FORCE and are the only separators in which the steam ALWAYS flows in one direction.

They cause no loss of pressure in the steam line and ENTIRELY eliminate shaking and vibration of steam pipes.

They are provided with extra large reservoirs which make possible HIGH initial pressure at the throttle.

There is absolutely not an ounce difference in pressure between the inlet and outlet of "Swartwout" Steam Separators.

They are tested at 400 lbs. Hydrostatic pressure and are guaranteed for 150 to 250 lbs. working pressure.

There IS a difference in Steam Separators. Send for booklet—a postal is all that is necessary.

THE OHIO BLOWER CO., CLEVELAND, O.
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That Separator is the Best

which will take steam after it has passed through any other make of Separator and remove moisture or oil. The VATER TWO-STAGE WILL DO IT. The reasons are obvious. Why not post yourself by writing.

Power Plant Specialty Co.,
245 S. Jefferson St., Chicago, Ill.

THERE'S ECONOMY

in the purification of live steam with a *Baum Separator.*

Try it for 30 days and see. If our claims are not fulfilled—there's no cost to you.

THE HERSHEY MACHINE & FOUNDRY CO.,
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The STRATTON Steam Separator

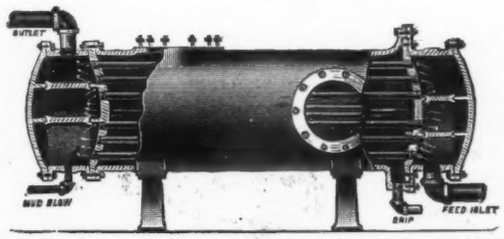
By centrifugal force all moisture is separated from the steam and absolutely

Dry Steam

delivered to the engine.

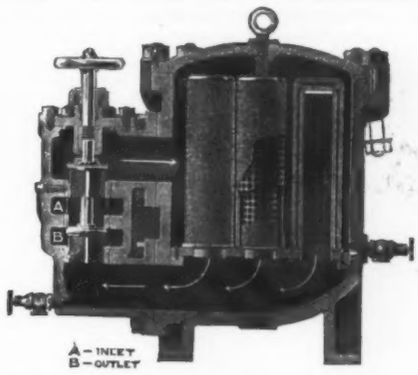
GOUBERT

Feed Water Heater



HORIZONTAL TYPE OF GOUBERT FEED WATER HEATER.

GOUBERT MFG. CO., 88 West St., New York.



WHERE boiler feed water is scarce or dear or must be purified it pays to filter the condensed exhaust steam from condensers, heating and drying coils, etc., through a **Blackburn-Smith Feed Water Filter and Grease Extractor.**

The result is increased output from the boilers and engines, a saving of 90% of water bills and enough heat to cut more than 5% from the coal bills. Condensed steam contains no scale-forming matter, therefore its use reduces boiler cleaning and repair bills.

Ask our engineers as to how to make this saving and how much it will amount to in your plant.

Write for Treatise "Feed Water Filtration."

JAMES BEGGS & CO.

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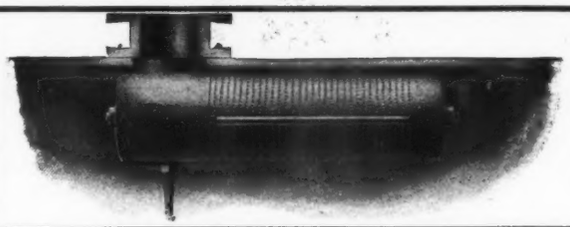

"THE POTTER" MESH SEPARATOR

Prevents tubes of superheaters scaling up

DRY STEAM GUARANTEED

POTTER SEPARATOR COMPANY

No. 1 Front Street Newburgh, N. Y.

Chas. N. Hays, Fisher Bldg., Chicago; Empire Bldg., Pittsburg; Wm. S. Haines Co., Philadelphia.

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Pumping Machinery Water Wheels

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Agencies in Principal Cities.

A CLEAN BOILER USES LESS FUEL.

Clean feed-water insures a clean boiler.

ADVANCE PURIFIERS

insure clean feed-water.

Ask for circular No. 30.

F. E. KEYES & SON,

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WE are especially anxious to have the **"Peerless"** placed where the inferior appliances have failed to operate, and if the **"Peerless"** does not fully demonstrate its efficiency you need not pay for it.

HUSSEY, McCANN & CO.,

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KELLEY-BERRYMAN

On a feed-water heater or hot water service heater is a GUARANTEE of PERFECTION

WE ALSO EXCHANGE AND REPAIR HEATERS

BENJ. F. KELLEY & SON SOLE MFGR.

120 LIBERTY ST. N.Y. 35 YEARS ON LIBERTY ST.

Exhaust Head.

Hoppes Cast Iron Exhaust Heads

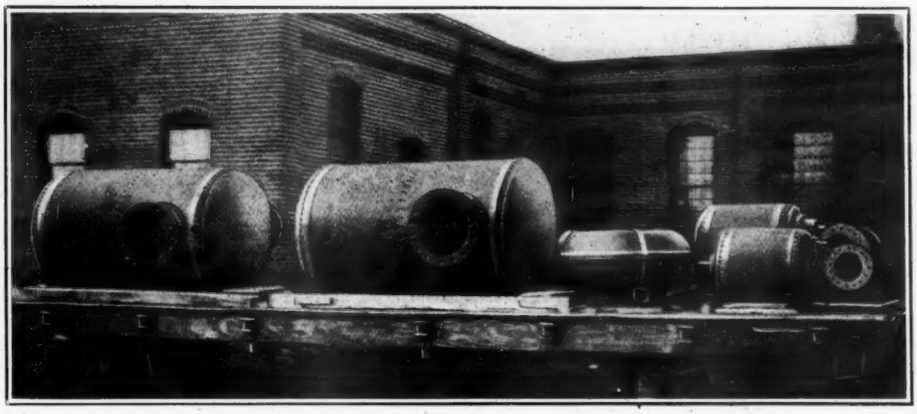
are designed to operate on the same plan as Hoppes Separators and have intercepting troughs partly filled with water.

No oil creeps over and runs down the outside and high efficiency has been secured by proper proportions and correct design. Being of cast iron they will last indefinitely.

Our prices are right.

Hoppes Steam Separators And Receivers

are so designed that all entrainment is caught in troughs partly filled with water. This prevents atomizing and gives absolutely dry steam. These separators are all extra large and act as receivers.

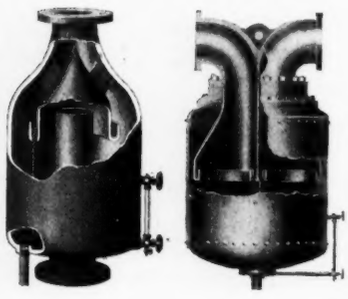


Special Oil Eliminators, Steam Separators and Exhaust Head for Anheuser-Busch, St. Louis, Mo.

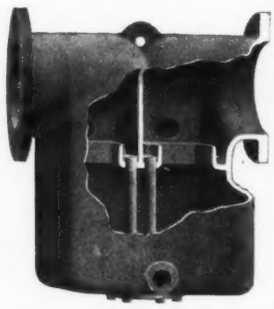
Hoppes Special Receiver Separators

We build Separator Receivers of all sizes and to any design to suit customers, and apply our principle of separation to the best possible advantage.

Give us a sketch or drawing of what you want and we will submit a complete design.



Hoppes Oil Eliminators



remove the oil and grease so thoroughly that the condensate may be used for boiler feeding or industrial purposes without danger.

Troughs partly filled with water prevent the oil creeping through and no baffle plates or other obstructions to the free flow of steam are used in the design.

ASK FOR CATALOGS OF ALL HOPPES SPECIALTIES.

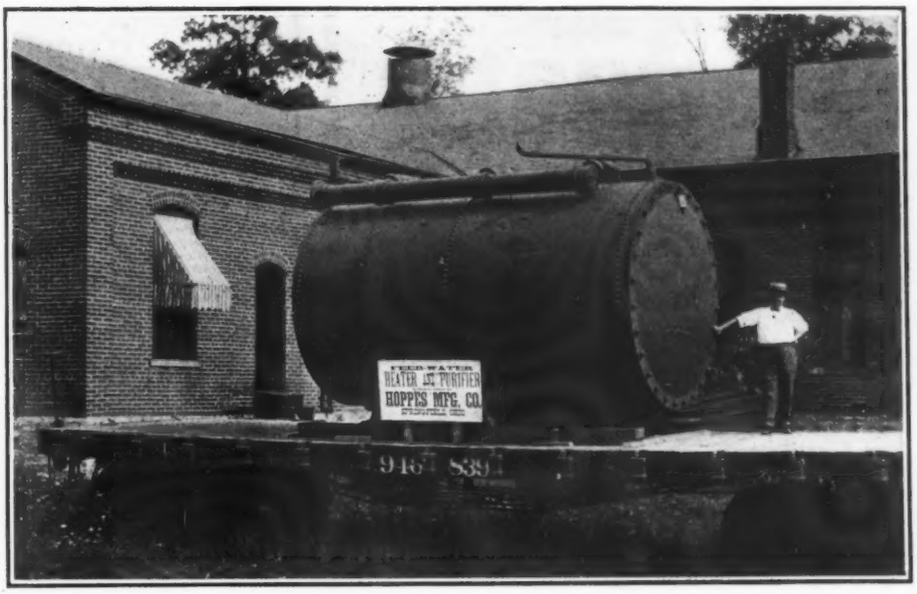
HOPPES MANUFACTURING CO., 19 Larch Street, SPRINGFIELD, OHIO.

Hoppes Exhaust Steam Feed-Water Heaters and Purifiers

Are built on engineering lines to suit the conditions under which they are to operate.

Standard Heaters and Purifiers for extremely bad water and class "R", "H" or "T" for medium bad or pure water and water that corrodes steel plate.

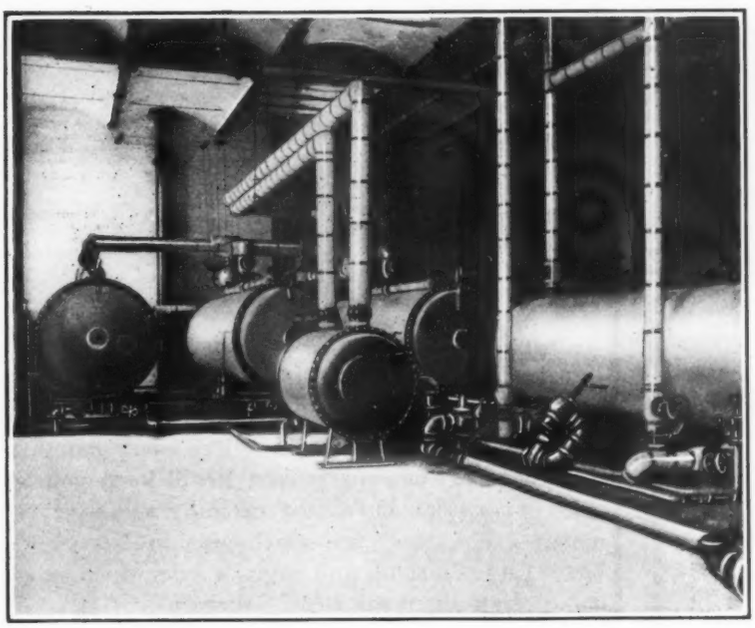
One feature is found in all these heaters which is not embodied in any other, and that is the principle of flowing the water along the under side of the pans in direct contact with the steam no matter how much lime the pans may retain.



16000 H.P. Hoppes Class "R" Feed-Water Heater and Purifier built for the Boston Elevated Railway Co.

We build heaters in all sizes from 25 to 40,000 H.P. and are prepared to make proposals, with specifications, and blueprints, for our regular or special machines on short notice. Write us stating requirements.

Hoppes Live Steam Feed-Water Purifiers



Hoppes Live Steam Feed-Water Purifiers and Exhaust Steam Feed-Water Heaters, Arctic Hygeia Ice Co., New York City.

are the most economical appliances for keeping boilers free from scale, as no chemicals are required.

They also act as reservoirs of energy to help over peak loads, being the best application of thermal storage yet devised.

All strains and shocks due to feeding water at low temperatures are avoided as the feed water is raised to practically the same temperature as the water in the boiler.

Our purifiers are in use all over the civilized world, and if you have trouble with scale, write to us. Water analized free for prospective customers.

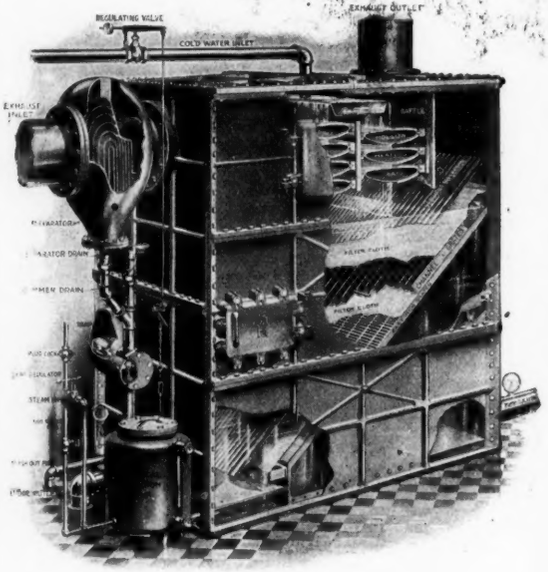
Send one quart of water by express prepaid.

SEND FOR ILLUSTRATED CATALOGS.

HOPPES MANUFACTURING CO., 19 Larch Street, SPRINGFIELD, OHIO.

The Marion Feed Water Heater

Incline Filter



Take Your Choice

The Marion Heater

OR

Boiler Scale

You don't want scale and you need not have scale if you have the

"MARION"

Both cost money but the "Marion" pays for itself while SCALE MAKES YOU DO THE PAYING.

The "Marion" pays for itself in less time than any other heating, filtering and purifying device and its maintenance cost is much lower.

Let us send full particulars.

Catalog G. 11 ?

The Marion INCLINE FILTER **and Heater Co.,**

Marion, Ohio, U. S. A.

FOR SALE.

Low Prices
Prompt Delivery

WATER TUBE BOILERS

1 300 H. P., Wickes vertical, 144 4 in. x 20 ft. tubes
2 200 H. P., Wickes vertical, 108 4 in. x 18 ft. tubes
3 200 H. P., Geary, 122 4 in. tubes
2 200 H. P., Wickes horizontal
1 160 H. P., Wickes horizontal, 98 4 in. x 16 ft. tubes
1 150 H. P., Wickes horizontal, 46 4 in. and 39 4½ in. tubes
1 150 H. P., Wickes vertical, 84 4 in. tubes
1 150 H. P., Wickes vertical, 80 4 in. tubes
1 150 H. P., Heine, 53 4 in. tubes, 16 ft. long
1 150 H. P., B. & W., 84 4 in. x 16 ft. tubes

CORLISS ENGINES

2 38 x 72 in. modern heavy duty Corliss, practically new
30 x 72 in. R. H., girder frame, Corliss
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22 x 60 in. L. H., girder frame, Harris
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22 x 48 in. L. H., girder frame, Corliss
20 & 40 x 48 in. L. H., Hamilton tandem comp.
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20 x 48 in. L. H., girder frame, Frick
20 x 48 in. R. H., girder frame, Hamilton
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20 x 42 in. girder frame, Harris
19 x 38 x 48 in. L. H., Allis tandem compound
18 x 48 in. L. H., girder frame, Wheelock
18 x 42 in. (pair) girder frame, Allis
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16 & 30 x 48 in. cross comp., Hamilton
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28 x 56 in. L. H., Buckeye, heavy girder frame
20 x 36 in. L.H., girder frame, Buckeye, Style A
20 x 27 in. R. H., four-valve, Russell
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18 x 27 in. L. H., Tangye frame, Russell
18 x 48 in. L. H., girder frame, four-valve, Wheelock
18 x 28 in. R. H., girder frame, Hill
16 x 18 in. Atlas, center crank
16 & 27 x 16 in. Westinghouse compound
16 x 16 in. Green, center crank, high speed
15½ x 15 in. center crank, Armington & Sims
15 x 16 in. Taylor-Beck
15 x 16 in. Valley, center crank
14 x 15 in. L. H., Myers
13 & 19 x 15 in. McIntosh & Seymour, tandem compound
13 x 22 x 13 in. Westinghouse, compound
13 x 13 in. center crank, Ideal
12 x 16 in. L. H., Tangye frame, Erie, class B
12 x 16 in. center crank, Ball
12 x 12 in. center crank, Buffalo, high speed
11½ x 17½ x 16 in. L. H., Buckeye, Style C
11 x 16 in. L. H., Atlas
10½ x 16½ x 12 in. Armington & Sims
10 x 12 in. center crank, Vim
9½ x 10 in. Wickes, center crank, new

DUPLEX PUMPS

20 x 8 x 16 in. Canton, outside packed plunger, 7 in. suc., 6 in. dis.
18½ x 12 x 16 in. Worthington, 10 in. suc., 8 in. dis.
17 x 7¾ x 15 in. Worthington, outside packed plunger, 5 in. suc., 4 in. dis.
16 x 9 x 12 in. Worthington underwriters fire pump
14 & 20 x 12 x 15 in. Worthington comp., 12 in. suc., 10 in. dis.
3 12 & 20 x 17 x 15 in. Worthington comp., 14 in. suc., 12 in. dis.
12 x 7½ x 10 in. Buffalo, 4 in. suc., 4 in. dis.
12 x 7 x 12 in. Hall, 5 in. suc., 4 in. dis.
12 x 7 x 10 in. Worthington, 5 in.suc., 4 in.dis.
10 & 16 x 8 x 12 in. Smith-Vaile compound, 8 in. suc., 7 in. dis.
10 x 6 x 14 in. Smith-Vaile, outside packed plunger, 5 in. suc., 4 in. dis.
10 x 6 x 10 in. Canton, 5 in. suc., 4 in. dis.
2 10 x 6 x 10 in. Worthington, 5 in. suc., 4 in. dis.
8 & 12 x 7 x 10 in. Worthington compound, 5 suc., 5 in. dis.
8 x 5 x 10 in. Canton, 5 in. suc., 4 in. dis.
7½ x 4½ x 10 in. Buffalo, 3 in. suc., 2½ in. dis.
7 x 4½ x 8 in. Hall, 4 in. suc., 3 in. dis.
6 x 4 x 6 in. Worthington, 3 in. suc., 2 in. dis.
5⅝ x 2¾ x 5 in. Worthington, with receiver 2½ in. suc., 1½ in. dis.
5¾ x 3½ x 5 in. Blake, upright 2½ in. suc., 2 in. dis.
4½ x 2¾ x 4 in. Canton, 1½ in. suc., 1½ in. dis.
4½ x 2¾ x 4 in. Laidlaw-Dunn-Gordon.

SINGLE CYLINDER PUMPS

20 x 14 x 20 in. Blake, 10 in. suc., 8 in. dis.
16 x 10 x 14 in. Blake, 8 in. suc., 6 in. dis.
16 x 7½ x 24 in. Wilson-Snyder outside center packed, 6 in. suc., 3½ in. dis.
14 x 9¾ x 18 in. Wilson-Snyder, 7 in. suc., 5 in. dis.
14 x 8 x 12 in. Niagara fire pump, 6 in. suc., two 3½ in. dis.
14 x 8¼ x 10 in. Wells No 21, 5 in.suc., 4 in.dis.
12 x 7 x 12 in. Holly Mfg.Co., 5 in.suc., 4 in.dis.
11 x 7½ x 10 in. Smith-Vaile, 4 in. suc., 3½ in. dis.
10 x 6 x 16 in. Titusville, 4 in. suc., 4 in. dis.
10 x 5 x 10 in. Pauling, 4 in. suc., 3 in. dis.

DEEP WELL PUMPS

Deming geared belt driven deep well pump head
12 x 24 in. Deane deep well pump
10 x 36 in. Cook
10 x 24 in. Knowles deep well pump
2 8 x 24 in. Deane simplex deep well pumps
6 x 16 in. Deane simplex deep well pump
5 x 36 in. Gould deep well pump

FEED WATER HEATERS

2000 H. P. Wickes, with iron pans
1500 H. P. Otis, 80 2½ in. brass tubes
1000 H. P. National
800 H. P. Wainwright, with 163 2 in. brass tubes
600 H. P. Erie City with brass tubes
500 H. P. Berryman, with brass coil
500 H. P. Wheeler with brass tubes
500 H. P. Webster vacuum with copper pans
500 H. P. Stillwell-Bierce horizontal live steam heater, with iron pans
400 H. P. Berryman upright
400 H. P. American, No. 16, with copper coil
400 H. P. Jacobs with brass tubes
200 H. P. Cooper with brass tubes
200 H. P. Jacobs, with 40 1¼ in. brass tubes
150 H. P. Pacific, with brass tubes
125 H. P. Pittsburg open type
100 H. P. Jacobs with brass tubes
50 H. P. Jackson with brass coils

We have on hand at all times upwards of three hundred boilers and engines of various types, a list of which will be found in our thirty-two page stock list published monthly and furnished free every month in the year to any one interested. It will keep you advised of our stock and if read carefully will save you money. We have large warehouses in New York, Jersey City, Pittsburg and Saginaw from which we can make very prompt shipment. Write us.

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NEW YORK BOSTON PITTSBURG PHILADELPHIA SAGINAW, MICH. CHICAGO SEATTLE

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Open Horizontal **Closed Vertical**

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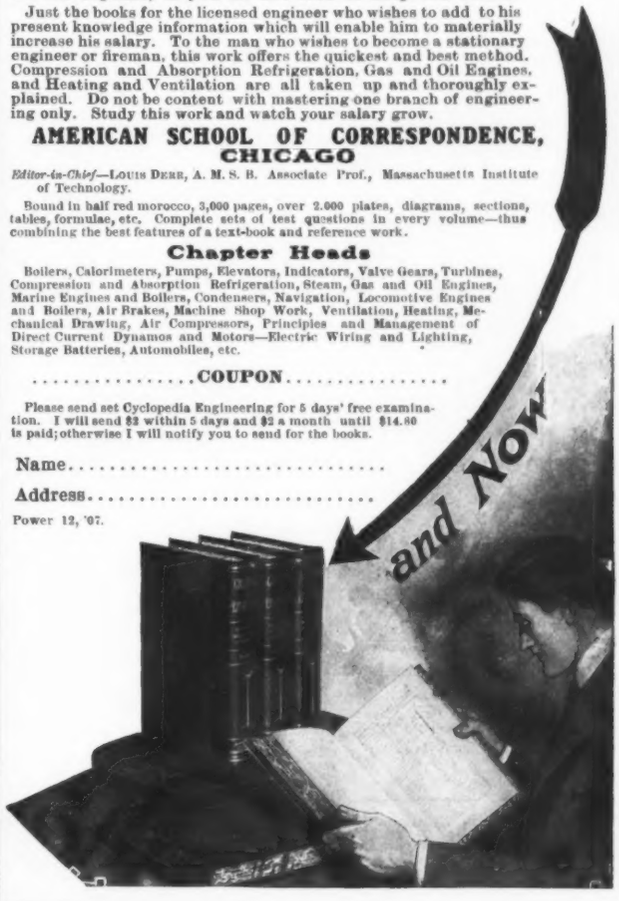

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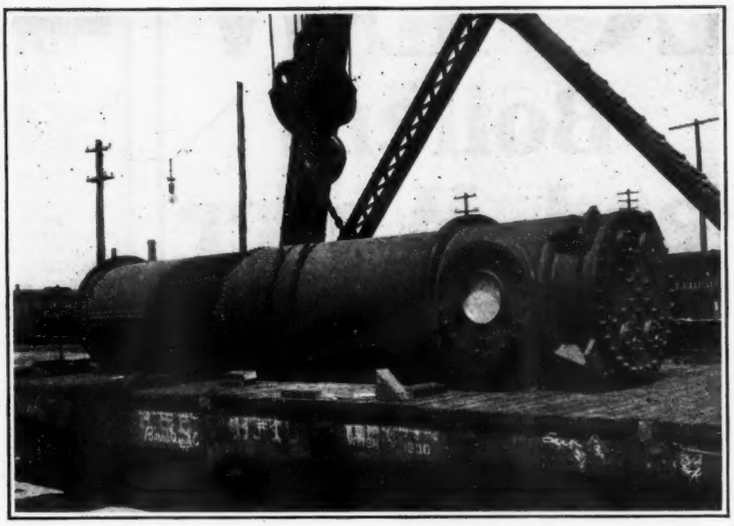

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THE SIMS COMPANY, Erie, Penna.

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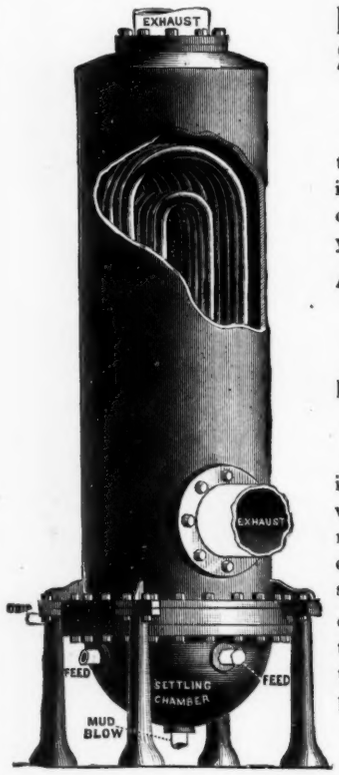

Putting Exhaust Steam To Any Use?

Are you permitting it to escape day after day, instead of using it to increase the efficiency of your plant?

Adopt the

Patterson-Berryman
Feed Water Heater and Purifier

Then you'll *know* that it not only effects worth while savings in equipment and repairs, but also creates a fuel saving that soon covers its initial cost. *Pure hot water* for the boilers by means of the exhaust—that's the point.

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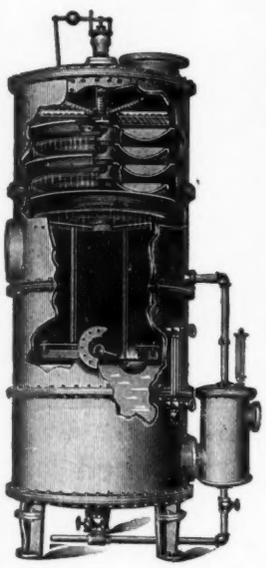
Expansion and Contraction Ruin Your Boiler



The PITTSBURGH FEED WATER HEATER

prevents this damage by furnishing feed water at 210°.

It also extracts all oil from the exhaust, impurities from the water and swear words from your vocabulary.

More power, less fuel, more results and less repairs.

BOOKLET?

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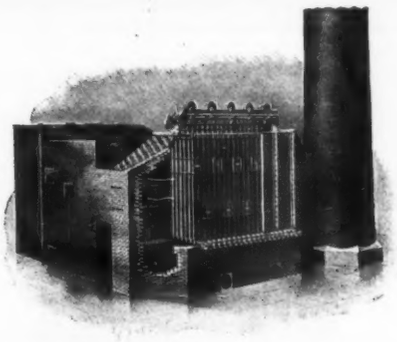


It Pays to Find a Place for the Green Fuel Economizer

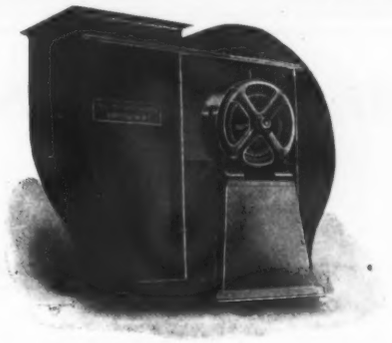
Many people realize that their present boiler plants are wasting a good percentage of fuel, and know further that this fuel could be saved and the capacity of the boiler plant increased by putting in a Green Fuel Economizer. Still they say that they have not room in their boiler house to install an economizer, and they, therefore, put off taking the matter up with us, and the waste of fuel goes on.

This is a mistake. We can usually find a place for the economizer without upsetting the arrangement or interfering with the operation of the existing plant. The economizer requires so little attention that it does not need to be in a very accessible place.

The installation of the economizer is often the only practicable way of increasing the boiler capacity without adding to the boiler house. This increase in the capacity is even greater than the increase in economy; for instance, if the boiler efficiency is increased by 13%, the capacity will be increased by 20%.

If you wish to know what we can do in your case, send a sketch showing the lay-out of your boiler plant, and a few particulars, such as the size and number of the boilers, amount of fuel burned, etc., and we will devise a suitable arrangement, and make an estimate which will show you just what can be done, and the possible saving.

For a full account of economizer practice, send for our Treatise, "106 P." If you are putting up a new plant, consult us before your designs have progressed too far for revision.



Green Electrically Driven Fans are Adapted for Every Purpose

The size and speed of a fan used to do a given amount of work, have a great influence upon the size of the motor and the amount of power required. We design our fans to use the standard motors on the market. These are well known as to quality, workmanship and efficiency, and the purchaser has the electric manufacturer's guarantee as well as our own to cover the electric part of the equipment.

As these motors are built by specialists and in large shops making a business of motor manufacture, they embody all the scientific improvements and the most suitable materials. For instance, the best quality of magnetic iron is used, the most improved arrangement of brushes, conductors, mechanical construction, etc., in other words, we believe in having motors built by motor manufacturers and fans by fan manufacturers.

We also believe that after we have done the engineering work to fit the two to each other, we can offer a better combination than by attempting to build both kinds of apparatus.

Above we show a Green Up-blast Exhauster driven by a directly connected induction motor, both mounted on the same base. We also supply engine and belt driven arrangements for every conceivable location; in fact, we make it a special point to build fans for special purposes.

Write for the New Fan Catalogue "P 104" and also for our special booklet on the Application of Fans.

The Green Fuel Economizer Company,

Matteawan, New York. 154

(SOLE BUILDERS OF THE GREEN FUEL ECONOMIZER IN THIS COUNTRY)

THE HEART OF SUCCESS IS

ECONOMY

True economy is making use of every means of production.

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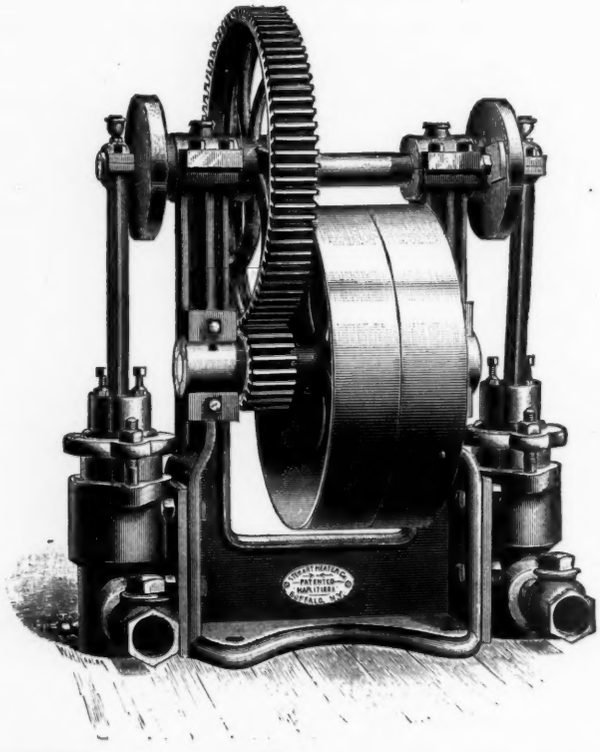
The OTIS TUBULAR FEED WATER HEATER and PURIFIER

uses your exhaust steam to raise the temperature of your feed water to 212° before it enters your boiler.

The heat of this steam would otherwise be wasted and the raise in temperature means a positive saving of a definite amount of fuel—moreover, the OTIS eliminates scale and removes oil and other impurities from the feed water.

We send the *Otis on trial;* if it is not well worth the money, ship it back at our expense.



OUR DOUBLE PLUNGER PUMPS

for furnishing water to your boiler, are the simplest in design, the most economical in first and final cost, and will do more work with less attention than the more expensive makes.

Can be run double or as two separate pumps.

You should have the catalog.

The Stewart Heater Co.

50 Norfolk Avenue, Buffalo, New York.

THE WHITLOCK COIL PIPE CO.,

HARTFORD, CONN., U. S. A.

NEW YORK OFFICE:
SINGER BUILDING, 85 LIBERTY ST.

BUILDERS OF

FEED WATER HEATERS.
WHITLOCK "PIPE JOINTS.
FLANGED AND BENT PIPE FOR HIGH PRESSURES.

COILS AND BENDS FOR ALL PURPOSES.
STEAM SEPARATORS.
EXHAUST HEADS, ETC.

We are the original designers and builders of Coil Feed Water Heaters with the new and improved outside header as illustrated above. All imitations are infringements of our patents.

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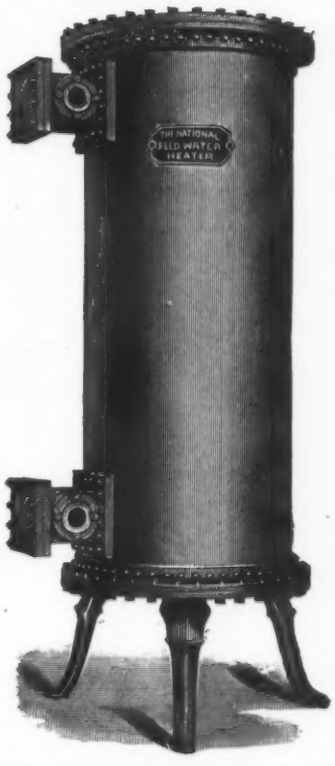
The National Feed Water Heater.

1,500,000 Horse Power In Daily Use.



These Heaters are characterized by

Simplicity, Cheapness, Reliability and Efficiency.

We are making Heaters of 1,000 Horse Power and above with the new style outside headers, with removable cover plates to the headers, affording access to the pipe ends. Any pipe or coil can be stopped off, if necessary, and the heater continued in regular use. These coils have a virtually constant ratio between the amount of their respective surfaces to their respective transverse areas. These Heaters supply water to the boiler at 200° to 212° F., and we manufacture the original and only genuine first-class Coil Feed Water Heaters.

The National Pipe Bending Co.,

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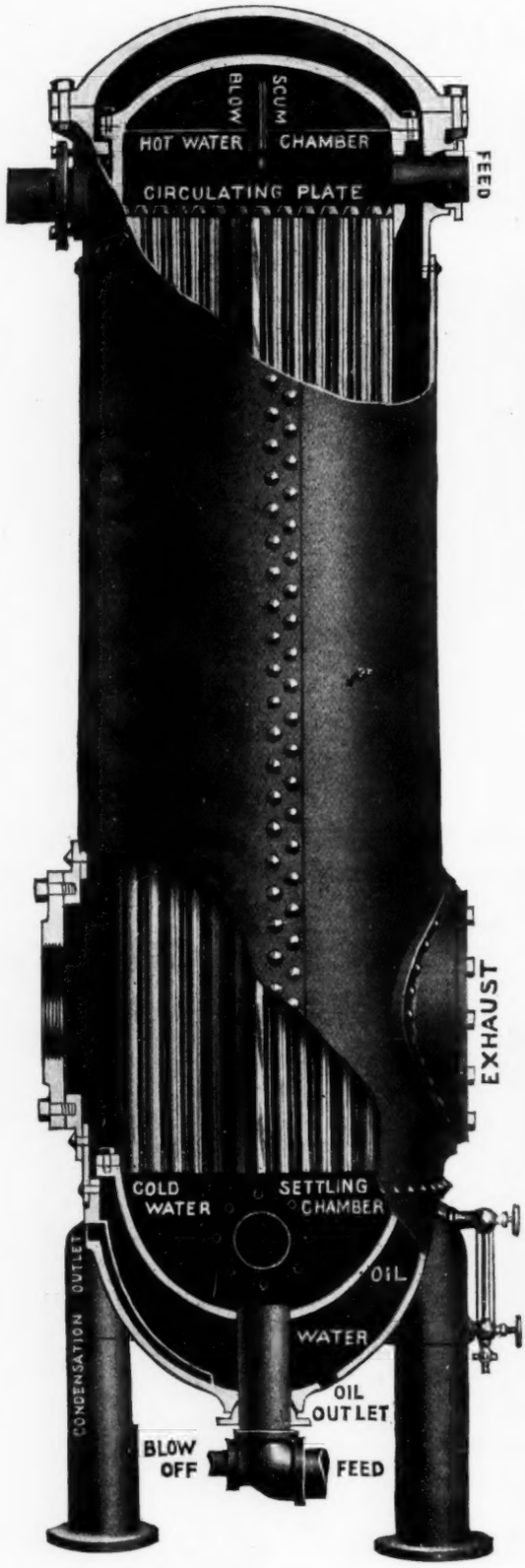
We also manufacture all kinds of Coils in iron, brass and copper pipe.



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Is THE CLOSED HEATER that can be cleaned without removing the piping, which incurs added expense in other types of closed heaters.

HIGHEST EFFICIENCY GUARANTEED.

Let us make an estimate on your Heater Requirements.

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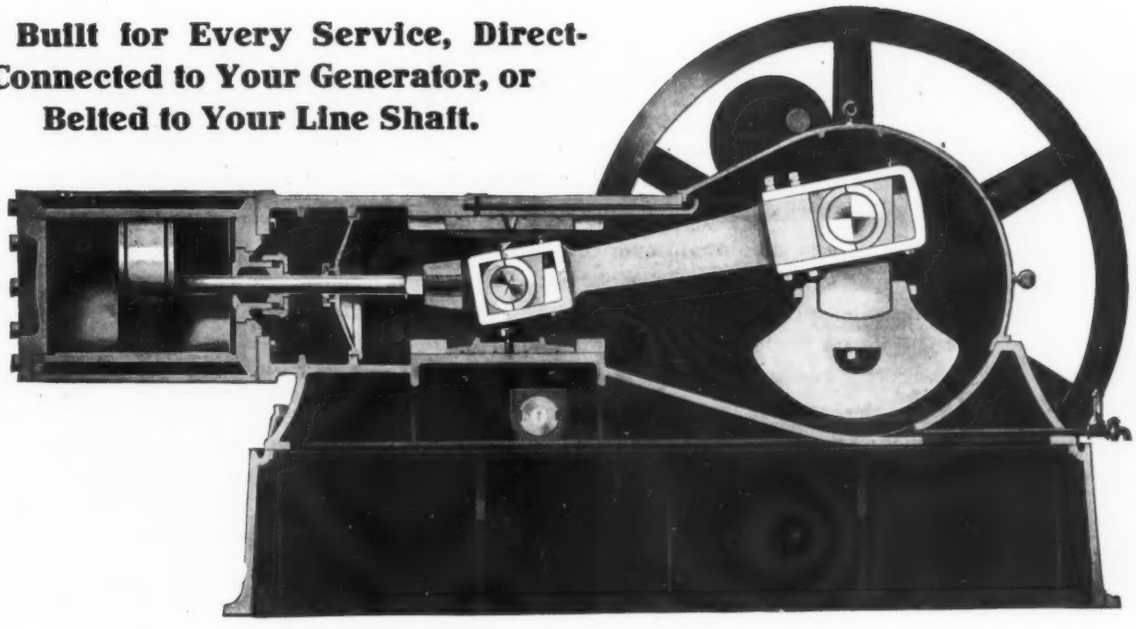
Are Built for Every Service, Direct-Connected to Your Generator, or Belted to Your Line Shaft.



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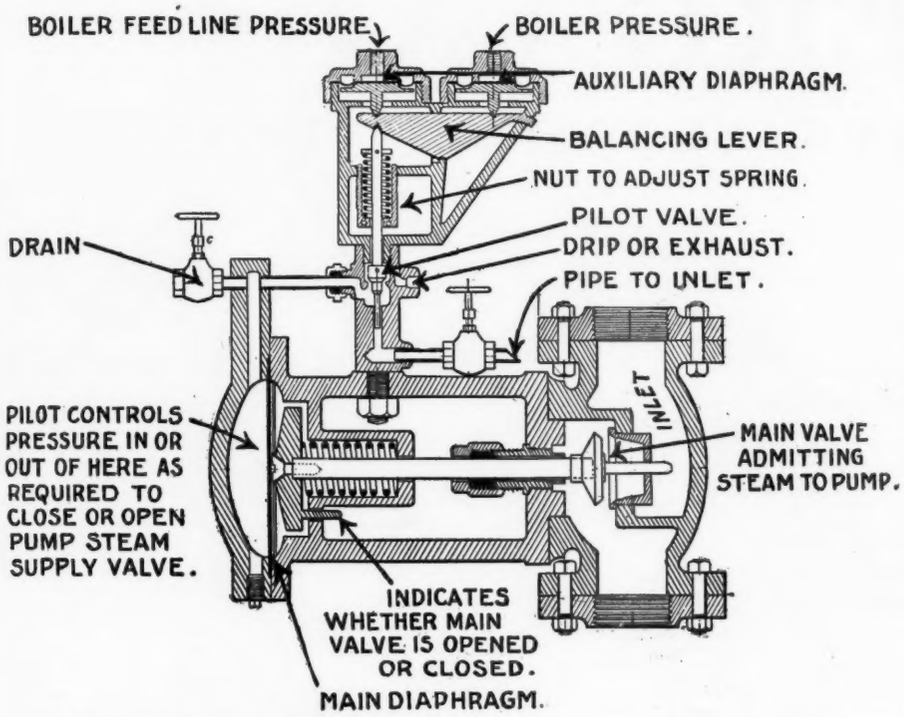
AND SUPPLY COMPANY

1203 PEACH STREET, ERIE, PENNA., U. S. A.

The Only Way To Control Boiler Feed Pumps


BOILER FEED LINE PRESSURE
BOILER PRESSURE.
AUXILIARY DIAPHRAGM.
BALANCING LEVER.
NUT TO ADJUST SPRING.
PILOT VALVE.
DRIP OR EXHAUST.
PIPE TO INLET.
DRAIN
INLET
PILOT CONTROLS PRESSURE IN OR OUT OF HERE AS REQUIRED TO CLOSE OR OPEN PUMP STEAM SUPPLY VALVE.
MAIN VALVE ADMITTING STEAM TO PUMP.
INDICATES WHETHER MAIN VALVE IS OPENED OR CLOSED.
MAIN DIAPHRAGM.

Why carry more pressure on the boiler feed line than you actually need? If the boiler feed pressure is fixed at one invariable point, it must necessarily be greater than the safety-valve blow off pressure. This is all right if the boiler pressure is also constant, but generally it fluctuates. If the boiler pressure falls, while the feed line pressure stays the same as before, the "excess" is too much for good results. Valves grind out quicker under the heavy pressure, the feed pump does more work, must have larger steam cylinders and takes more steam than would otherwise be necessary, and if the feed is hand controlled, the fireman must set the feed valve oftener.

A better plan is to use a pump governor that will hold the feed line pressure at a fixed "excess" over the boiler pressure

The Squires Excess Pump Governor

shown herewith, does this. The pump line pressure and the boiler pressure act on two diaphragms balanced on the ends of a lever. Variation of the difference between these pressures determines which way the lever shall tilt, and the movement of the lever regulates the pump.

The excess pressure of one diaphragm over the other is opposed by a small spring, and by adjusting this spring the excess may be made great or little, as desired. When the pump line pressure falls, the spring and boiler pressure together get the best of the line pressure and open the pilot valve, letting more steam go to the pump. As the line pressure comes up again it closes the pilot. It doesn't do this by jerks, but evenly and smoothly, so that the pumps are going all the time.

This governor keeps the **"excess"** exactly the same, no matter what the boiler pressure may be; for instance, on shipboard the Squires Excess Governor holds the feed line pressure a fixed number of pounds above 250 lbs. per sq. in. on the voyage, and the same number above perhaps only 50 lbs. at the dock. We guarantee this to be the most accurate Pump Governor on the market, and we will send it for 30 days' free trial with that understanding. If you can find a better one, send the Squires back at our expense.

We also sell the Squires Feed Water Regulator, which will keep the water level at the proper place, no matter how erratic the demand for steam.

Write for catalogue and name of nearest dealer.

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THE WATSON MACHINE COMPANY

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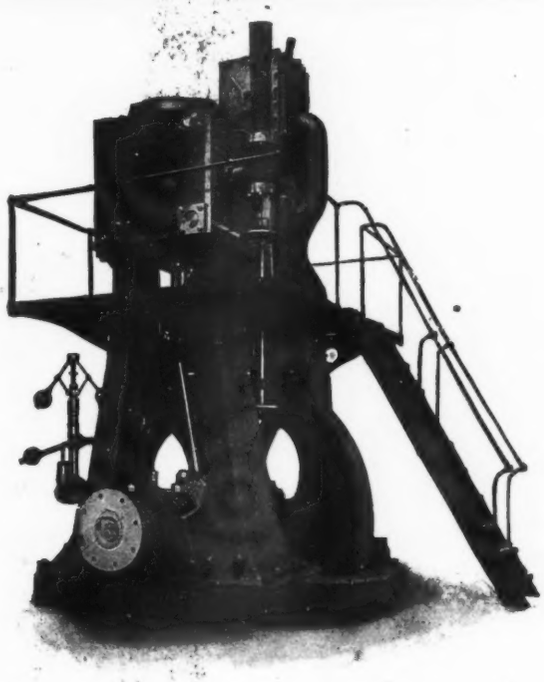

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PUMPS

COOLING TOWERS

WAINWRIGHT

HEATERS

COOLERS

EXPANSION JOINTS

SEND FOR CATALOGUE No. 6.

ALBERGER CONDENSER COMPANY

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Reeves & Skinner Machinery Co., 617 Chemical Bldg., St. Louis, Mo.

Branch Office: 205 La Salle St., Chicago.

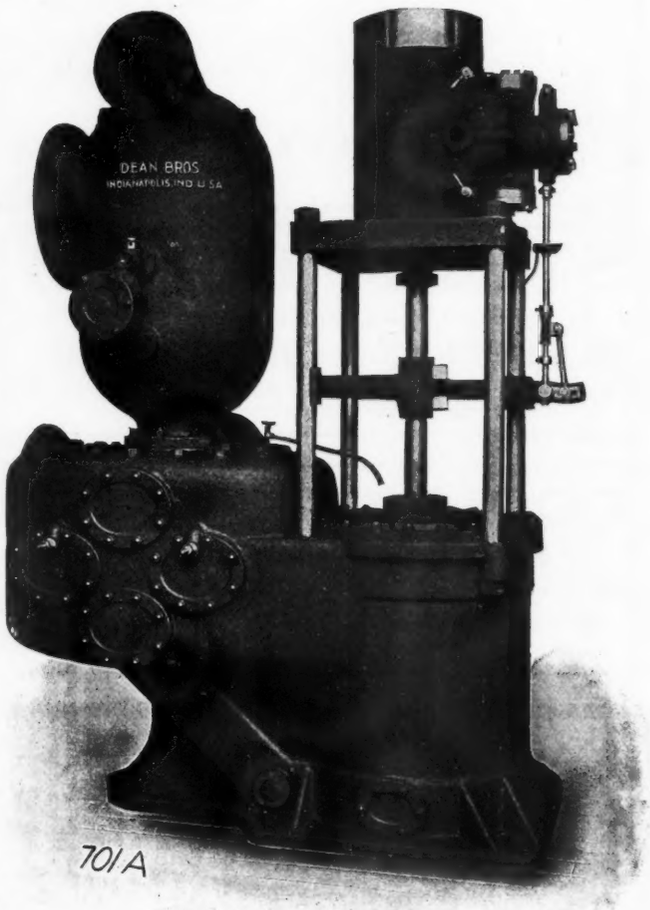
DEAN BROS. STEAM PUMP WORKS

INDIANAPOLIS, IND.

CONDENSERS

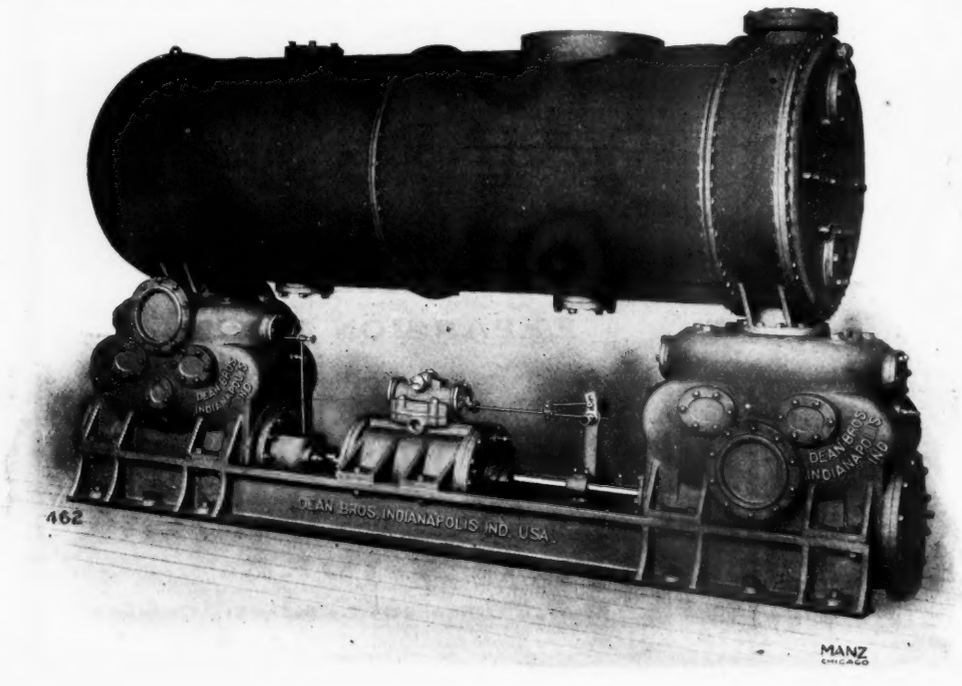
VERTICAL DOUBLE-ACTING AIR PUMP AND JET CONDENSER—An Independent Apparatus for Condensing Engines—See Cut at the Right.

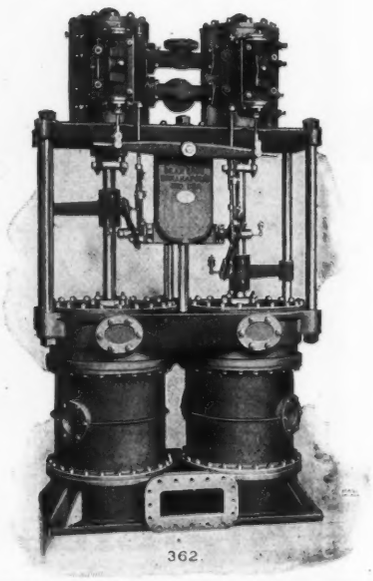
There are no valves in the piston. Both suction and discharge valves are in the valve chest at the side of cylinder. All valves are quickly accessible through hand holes. The piston rods are separable at the cross heads. Tapering keys are used to hold them in place. The cylinder head can be easily removed and taken entirely out of the way, for inspecting interior of cylinder or for repacking the piston. The piston rod stuffing box is provided with a water seal to prevent air from entering. All the valves are accessible without disturbing any part of the pump. It is double acting and therefore double the capacity of a single acting apparatus of the same size. It occupies but little floor space. The stroke is instantly adjustable. The vacuum is the highest practically attainable.



DEAN BROS. SURFACE CONDENSER—See Cut Below.

The tubes are of brass, specially made for the purpose, and are tinned inside and outside. The tube heads are of solid brass, with brass glands and cord packing of the style adapted by U. S. government engineers. Baffel plates are arranged for distributing the steam and protecting the tubes at the opening. The steam is also diffused over tubes by traverse plates. The tubes are supported at their centers to prevent sagging, and stop lugs are provided to prevent tubes from "creeping." Without such stops the tubes by contraction and expansion are liable to be drawn out of the heads.

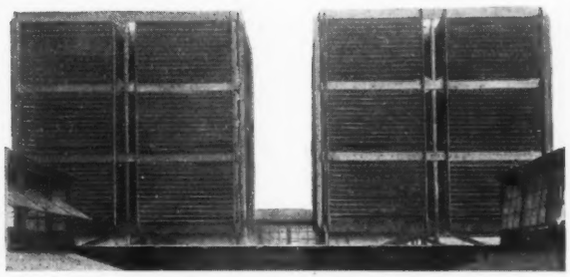




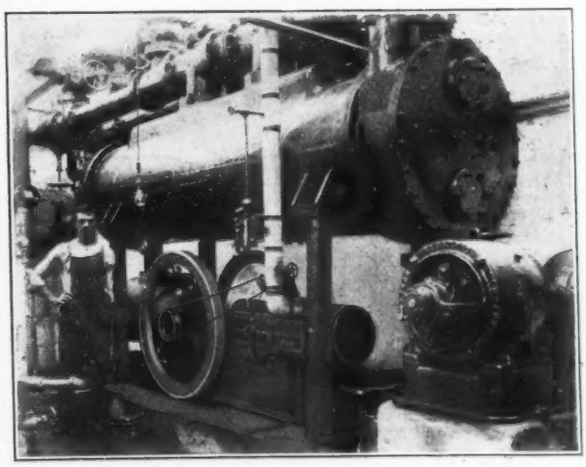
DEAN'S PATENT TWIN CYLINDER AIR PUMP

This pump is designed for use in connection with surface and jet condensers. It is the only Twin Cylinder Air Pump that is convertible into separate pumps.

HIGH VACUUM APPARATUS



Wheeler-Pratt Water Cooling Towers



Philadelphia Auto Transit Co's
Condensing Equipment
furnished by
C. H. WHEELER M'F'G CO.

Surface and Jet
CONDENSERS

Suction Valveless
AIR PUMPS

Feed Water
HEATERS

Duplex, Boiler Feed
Tank, and Pressure
PUMPS

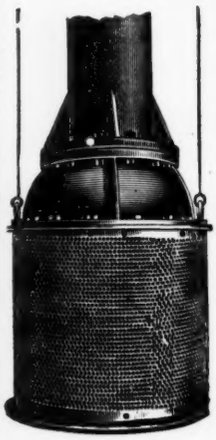
Water Cooling
APPARATUS

C. H. WHEELER MANUFACTURING CO.,
Head Office and Works: PHILADELPHIA.
New York Chicago Atlanta Pittsburg St. Paul Seattle San Francisco

What Protection Have You For Your Water System?

Patented May, 1899. View No. 2.

It is far better not to have any protection at all, unless you adopt a *good* one. This *Continuous Service Foot Valve* is proving equal to every test. Closes the door to *all* refuse. *Safest* suction pipe protector. Just as efficient in shallow water.



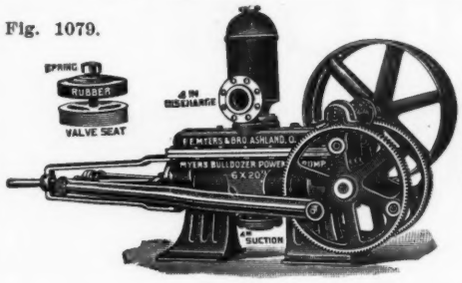
Patented May, 1899. View No. 1.

Ask for the descriptive leaflet.

The Newman Manufacturing Co.,
26 Cortlandt Street, :: NEW YORK.

Myers Power Pumps
Horizontal and Vertical

Fig. 1079.



Myers Bulldozer Power pump. Fig. 1079. No. 363. List Price, $250.

Myers Bulldozer Power Working Head. Fig. 813. No. 359. List Price, $75.

Fig. 813.

A full line of Bulldozer Power Pumps, Working Heads, Pumping Jacks, etc., designed for use in connection with Gas or Gasoline Engines, Electric Motors, Horse-power or any Belt Power. Send for Catalog and prices.

F. E. Myers & Bro.,
Ashland, Ohio.

Export Office:
B 17-21 Produce Exchange,
New York City.

Do you want a high duty air pump that won't stop? Made in two styles—single, for engine work—two stage, for turbine work.

The air pump is operated by a Corliss engine with variable speed control. Engine and air pump both accessible for cleaning and adjustment without taking down.

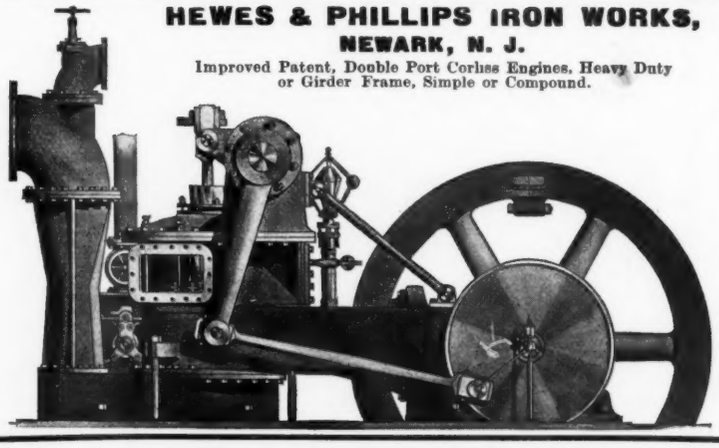
New Corliss Engines for Immediate Delivery		Corliss Engines for 30 Days Delivery	
1 10x24,	50 H. P.	2 10x24,	50 H. P.
2 12x30,	75 "	1 12x30,	75 "
1 14x36,	115 "	2 14x30,	100 "
1 16x30,	126 "	1 16x30,	126 "
1 16x36,	150 "	1 16x36,	150 "
1 18x42;	200 "	1 18x36,	190 "

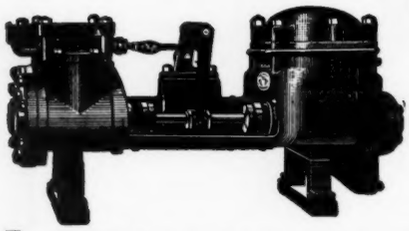
Second-Hand Engine.

Two 16x38 Corliss engines 150 Horse Power capacity each, in first class order, for immediate delivery.

HEWES & PHILLIPS IRON WORKS,
NEWARK, N. J.

Improved Patent, Double Port Corliss Engines, Heavy Duty or Girder Frame, Simple or Compound.





FAIRBANKS-MORSE STEAM PUMPS For Every Service.

Built from the most improved designs, of the best materials by expert workmen. Send for Catalog No. 648 SP.

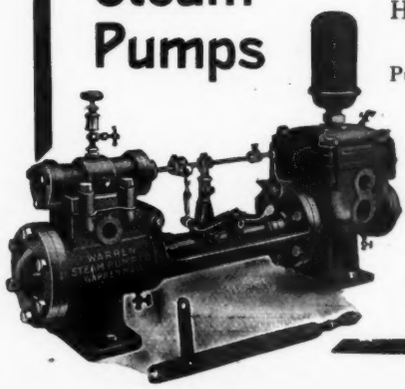
Fairbanks, Morse & Co.,
CHICAGO, ILLINOIS. **No. 12 Dey St., NEW YORK CITY.**

Steam Pumps

of the Highest Class.

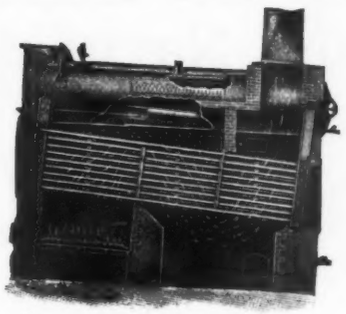
Repairing of Pumps a Specialty.

Send for Catalogue.



Warren Steam Pump Co.,
WARREN, MASS., U. S. A.

Water Tube Boilers



All Wrought Steel Construction.

Ask for 1905 Catalog P. W.

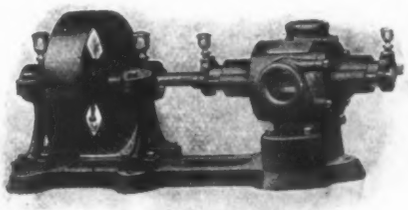
Established 1865.

E. Keeler Co.

Williamsport, Pa.

New York, Philadelphia, Chicago, San Francisco, Wilkesbarre and New Orleans.

The Blackmer Rotary Pump

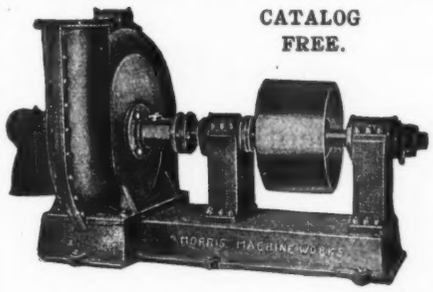


is better adapted to a large variety of uses than any other made. It is made in high and low pressure styles for hot and cold, thick or thin fluids. It leads them all in Simplicity, Durability, Efficiency and Economy. Get the catalog.

Blackmer Rotary Pump, Power & Mfg. Co.

201 Sheriden Ave., Petoskey, Mich.

We Make a Centrifugal Pump For Every Use



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to which such pumps are adapted. We have been at it for nearly forty years. We make more kinds than any other maker, and we build them in the way that long experience and careful study have shown to be the best way. You know the advantages of Centrifugal Pumps in general; but there are other advantages which we believe are peculiar to our Pumps and we want you to know them.

NEW YORK OFFICE: 39-41 Cortlandt Street.

MORRIS MACHINE WORKS,

Baldwinsville, New York, U. S. A.

DEANE OF HOLYOKE.

Single Vertical Double Acting Fly Wheel Vacuum Pump with Jet Condenser.

Particularly adaptable for Steam Engines and for the High Vacuums required for Steam Turbines.

A most efficient counter-current condenser, occupying minimum floor space and extremely economical in steam consumption.

The valve-areas are ample, water-passages large, and the water-valves are carefully sealed.

All parts are readily accessible.

Write us for Specification D-38.

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Works, Holyoke, Mass. **114 Liberty Street, New York.**

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Keep The Heat In The Pipes
Dollars Will Just Naturally

Carey's 85 Per Cent Pipe

There's a reason why the foremost power users in the country specify and purchase "CAREY'S."

There's a reason why the largest department stores, finest hotels and greatest profit-earning factories insist on "CAREY'S."

There's a reason why whenever a great Exposition is planned, CAREY'S PIPE COVERINGS are included among the absolute necessities for the various power plants.

The man who pays the bills can tell you why. Ask any power user.

We do not claim that there are no other pipe coverings. There are.

And neither do we claim that "CAREY'S" are cheaper in initial cost than any other. They are not.

But we DO claim that we have a pipe covering far superior and infinitely more lasting than the best of our followers.

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Where It Belongs And The Stay In Your Pockets

Carbonate Magnesia Coverings

Carey's Coverings are absolutely fire-proof and are positive non-conductors of heat. Their use on steam pipes stops steam condensation forever and guarantees dry steam to your cylinders. The heat is kept right where it belongs—within the pipes. Thus loss of power is prevented and excessive fuel bills eliminated.

It's a proven fact that Carey's Coverings pay their original cost every 6 or 8 months. Twice a year they declare 100% dividends in cost price alone. And once applied, they're on for good—no danger of charring or crumbling.

If these are not sufficient reasons to warrant a try-out, our catalog will reason with you further.

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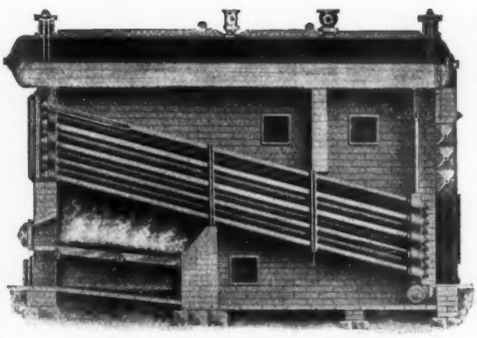
TUDOR

The Compounding Interest BOILERS



Tudor Sectional Water Tube Boiler.

We are specialists along the lines of boiler manufacture. Way back in 1834 we "started shop," and our present success is due to experience and careful methods of manufacture. Here's what we make and guarantee.

HORIZONTAL AND VERTICAL WATER TUBE BOILERS, *steel plate and sectional types*, HIGH PRESSURE AND STANDARD TUBULAR BOILERS, AIR RECEIVERS, HIGH PRESSURE DRUMS, TANKS, OPEN AND CLOSED FEED WATER HEATERS AND STEEL PLATE WORK OF GENERAL CHARACTER.

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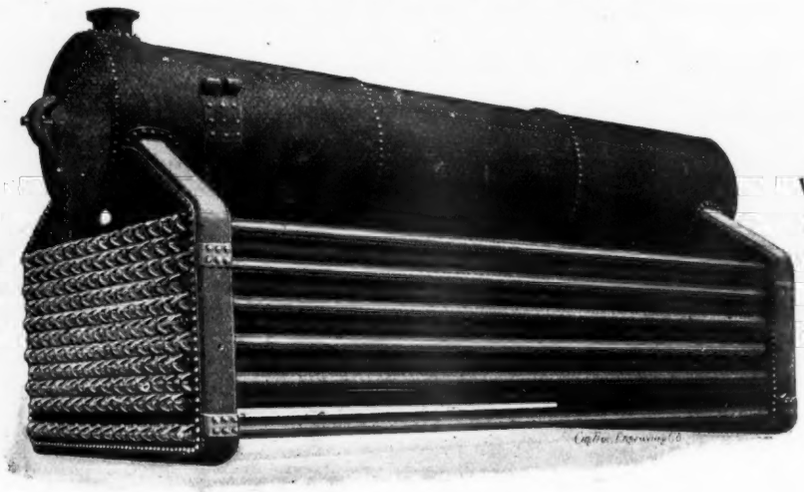


Write for Catalog and full Particulars.

Tudor Steel Plate Type Water Tube Boiler.

The Tudor Boiler Mfg. Co.,

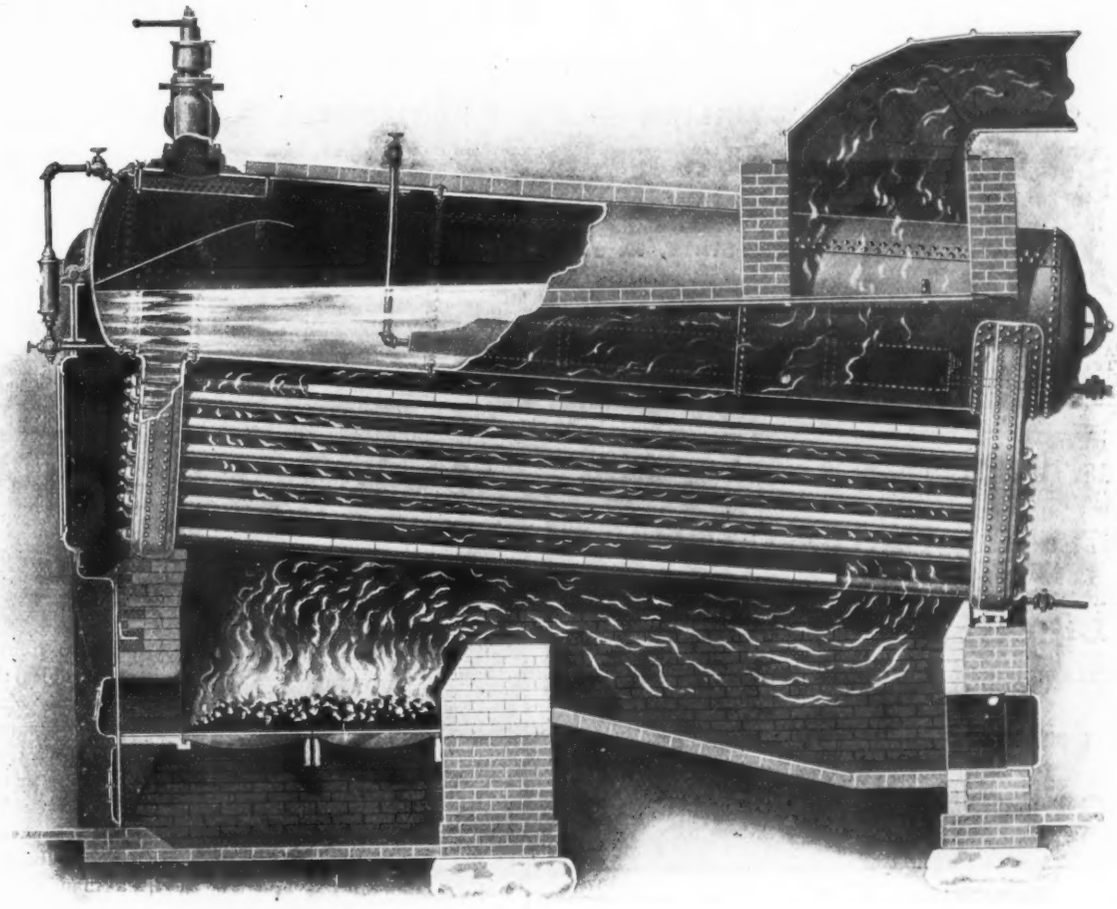
Established 1834 **Incorporated 1868**

CINCINNATI, OHIO, U. S. A.

FRANKLIN WATER TUBE BOILER

Built of Wrought Steel throughout
Large Grate Surface
Unimpeded Circulation
Easy to Clean
Large Forcing Capacity
Supported independent of fire fronts
Large Steam Capacity
High Furnace Temperature
Economy of Floor Space
Safe Under High Pressure

TEN SQUARE FEET OF HEATING SURFACE PER HORSE POWER



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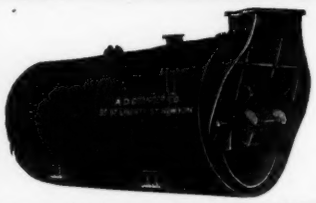
Sole Builders

TROY, NEW YORK, U. S. A.

General Sales Office

39 Cortlandt Street, New York

Philadelphia, Pa. Chattanooga, Tenn. St. Paul, Minn. San Francisco, Cal. Los Angeles, Cal.



OSWEGO BOILERS

STANDARD HORIZONTAL RETURN TABULAR—
Scotch — Locomotive — Vertical and Manning Types

OSWEGO — McNAULL WATER TUBE

SELF SUPPORTING STEEL STACKS,
TANKS, BREECHINGS, STEEL PLATE CONSTRUCTION.

Write for Bulletin No. 3-P.

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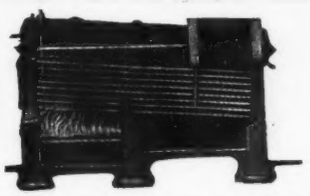
NEW YORK - PHILADELPHIA - PITTSBURG.



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Pennsylvania Building,
Philadelphia, Pa.

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NEW YORK—
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PITTSBURG—
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BABCOCK & WILCOX — STIRLING — A & T HORIZONTAL — CAHALL VERTICAL

WATER TUBE STEAM BOILERS

STEAM SUPERHEATERS — MECHANICAL STOKERS

Works: BAYONNE, N. J. — BARBERTON, OHIO.

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Power Lighting | Pumping Mining

MACHINERY OF THE HIGHEST GRADE

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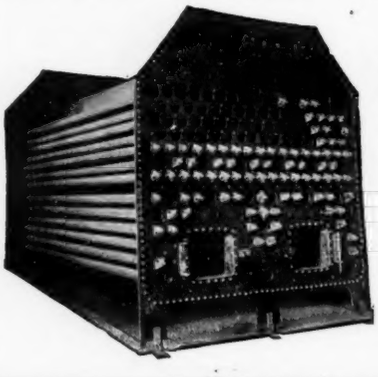
CORRESPONDENCE SOLICITED

DETROIT WATER TUBE BOILER
IMPROVED



A first-class, modern, economical and safe steam generator for high pressures. Experience has demonstrated its superiority.

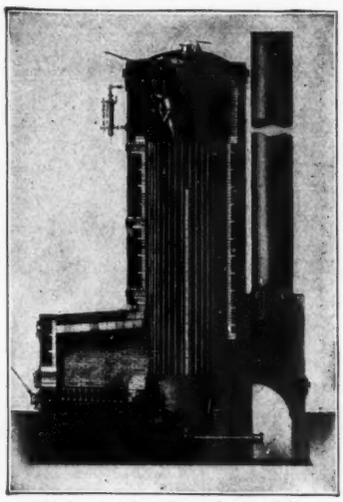
We simply guarantee results

send for illustrated catalog and determine for yourself the possibilities from our special construction.

Detroit Water Tube Boiler Company,
226 Mt. Elliott Ave.,
DETROIT, MICH.

The Wickes Vertical Water Tube Boiler.

IS IT ACCESSIBLE?



Cut shows position of man cleaning. Is it laborious compared with usual forms?

Two joints broken, (man holes) the Wickes Vertical Water Tube Safety Steam Boiler is open for inspection and cleaning in the minutest detail. Every tube can be looked through, every tube cleaned by a man standing erect (his best position for work) in the steam drum. The man can move about freely in the drum, and is not cramped in his work. Many prominent manufacturers open, clean and close the Wickes Vertical Water Tube Safety Steam Boiler for $1.65.

Let us send you further particulars.

WICKES BROTHERS
Saginaw, Michigan.

New York Philadelphia Boston Chicago, Ill. Detroit, Mich.
Pittsburg Birmingham New Orleans Scranton, Pa. Canton, Ohio

DO YOU KNOW

that a stationary Tubular boiler will make steam as cheaply for you as any kind of boiler you can buy?

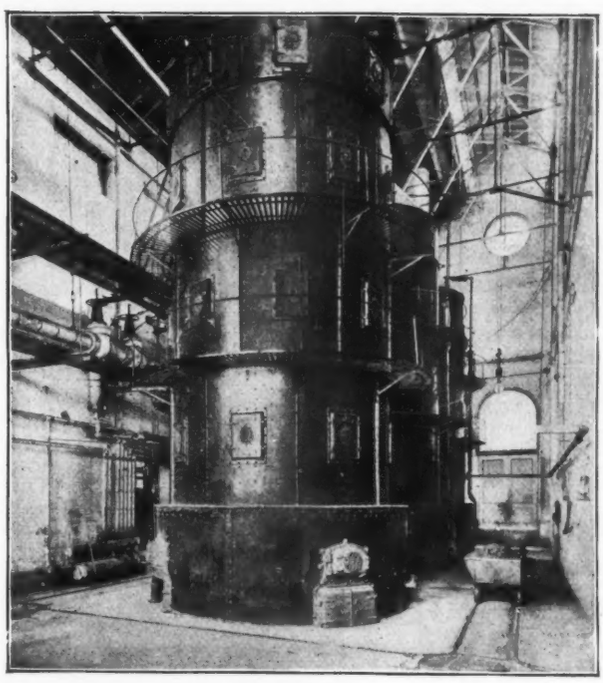
WE KNOW HOW

to do it and will tell you if you buy one of them from us.

They're cheap in first cost and also *very* durable.

CHANDLER & TAYLOR CO.
INDIANAPOLIS, INDIANA.

"Climax" Boilers are Safe Guardians of Safety & Economy



They're the highest development of human skill and ingenuity—the result of years of careful planning and deep research along the right lines.

"Climax" Boilers are found today in the largest manufacturing plants and power houses in the country. No great Exposition is complete without them, and they're medal winners on two continents.

"Climax" Boilers are absolutely reliable. They'll guard your profits, your property and your life. They'll get full returns from every piece of coal and drop of water, and in a thousand and one ways they'll teach you the true meaning of "boiler satisfaction."

We also make Steel Stacks, Tanks, etc.

Write for a Catalog.

THE MORRIN CLIMAX BOILER CO.,
BROOKLYN, NEW YORK.

ALLAN ANTI-FRICTION METAL
A ALLAN & SON NEW YORK
1500
TRADE MARK

A. Allen & Son

Inventors and
Sole Mfgrs.

486 Greenwich St.,

New York City.

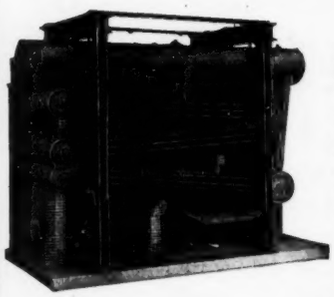
Mr. Engineer:

For years we have been endeavoring to draw your attention to the fact that cast-iron bull rings, working in cast iron cylinders, greatly increase friction and wear.

There is but one proper construction for pistons. They should be faced with a metal possessing excellent anti-friction qualities, a melting point sufficient to resist the heat conditions in the cylinder, and having a contraction and expansion equal to cast iron. A metal having these qualities you will agree must give better results than cast iron against cast iron.

ALLAN METAL has these qualities. We have convinced many, but so far have failed in our endeavors to convince you.

Give us an opportunity to argue our claim. We can save you money in re-boring cylinders and replacing bull rings.



The Unique Arrangement

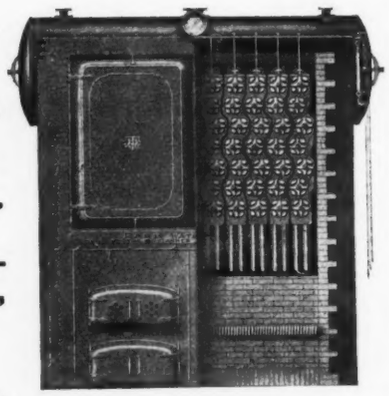
of the VOGT WATER TUBE BOILER perfectly provides for the FREE EXPANSION and CONTRACTION. As the water passes back and forth through the hot gases three times before reaching the steam drum, the circulation is three times that of usual boiler types.

How About Estimates and Other Details?

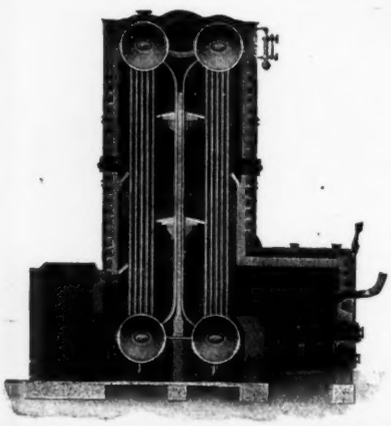
Henry Vogt
Machine Co., Inc.,
Louisville, Ky.

PARK
Water-Tube
BOILERS

Write to-day for our handsome new catalog "P"



The D. D. Flanner Boiler Co.,
Successors to
Toledo Boiler Works Co.,
151 Cleveland St., Toledo, O.

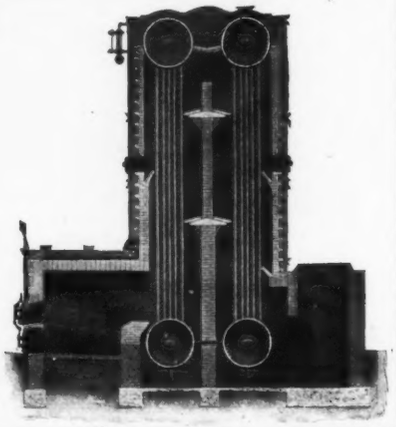


The Rust Water Tube Boiler

Safe
Simple
Economical
Durable
Accessible

THE RUST BOILER CO.,
Pittsburg, Pa.

THE RUST ENGINEERING CO.
BIRMINGHAM, ALA., and NEW ORLEANS, LA.
SOUTHERN AGENTS



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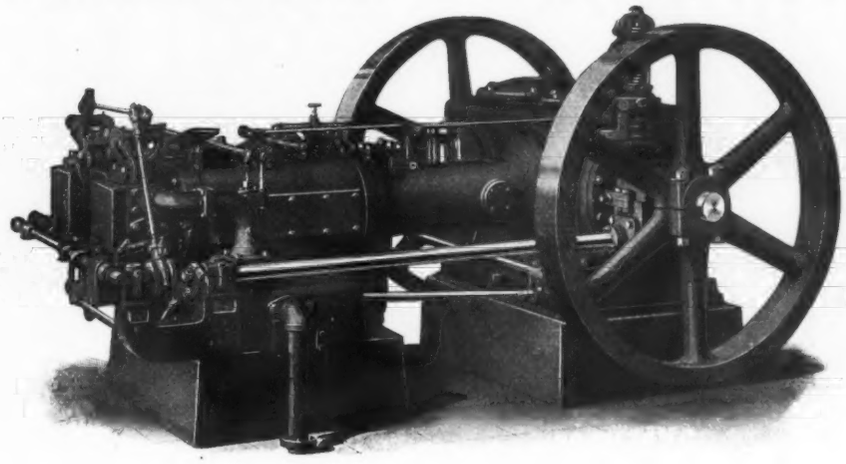
SIMPLE, ECONOMICAL, DURABLE.

ESPECIALLY ADAPTED TO DRIVING ELECTRIC GENERATORS.

BUILT BY BUCKEYE ENGINE CO., SALEM, O.

TYPES.	POWERS.
Single Acting Two-Stroke Cycle.	25 H. P. to 300 H. P.
Double Acting Two-Stroke Cycle.	300 H. P. to 6000 H. P.
Double Acting Four-Stroke Cycle.	500 H. P. to 6000 H. P.



We still maintain our reputation for independent thought and action and for keeping abreast of the times, and in presenting the BUCKEYE GAS ENGINE, Engineers and Purchasers will note that we are originators and leaders in this new line, as we always have been in our Steam Engine practice.

WE CUT FROM NEW CLOTH.

WRITE US WHEN WANTING EITHER GAS OR STEAM ENGINES.

THE JACOBSON GAS ENGINE

We build from 20 H. P. up to any size required.

QUICK SHIPMENT

FROM STANDARD STOCK NOW IN COURSE OF CONSTRUCTION

30 H. P. to 220 H. P.

ON ILLUMINATION AND NATURAL GAS.

ON PRODUCER GAS

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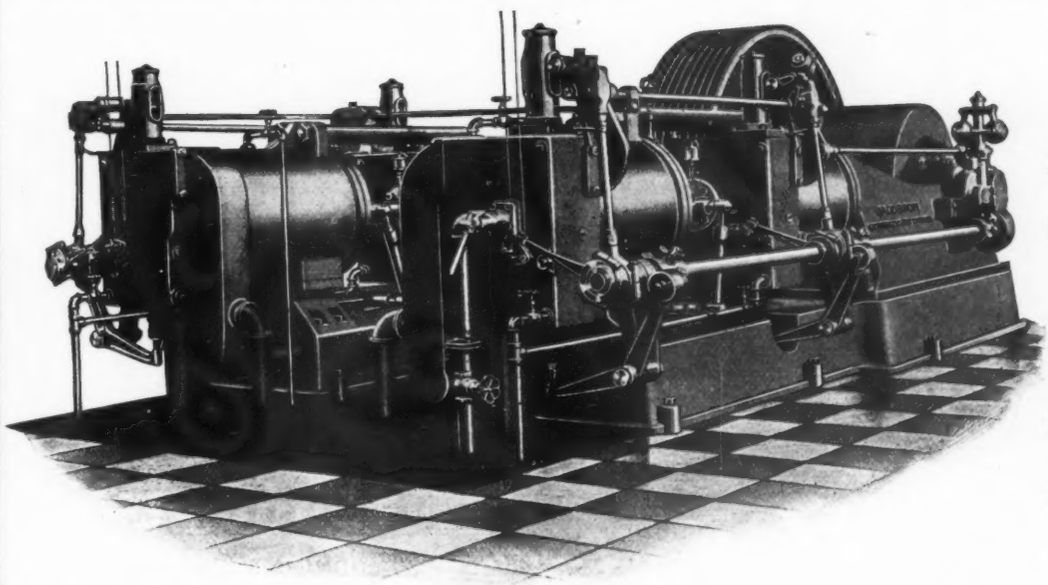

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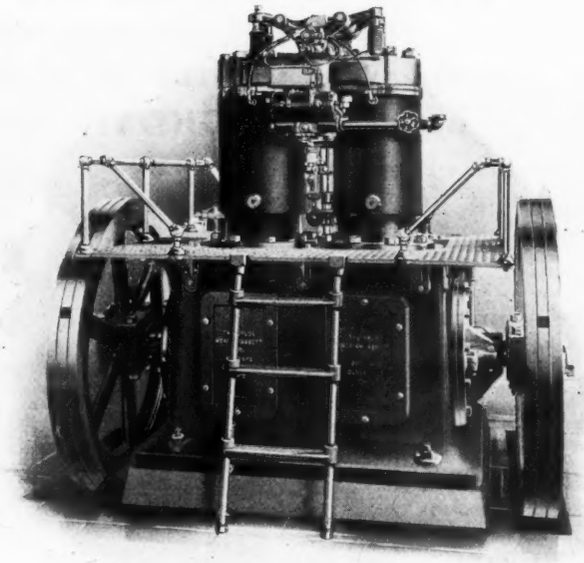
THE JACOBSON ENGINE CO., Main Office and Works: CHESTER, PA.

Results Count

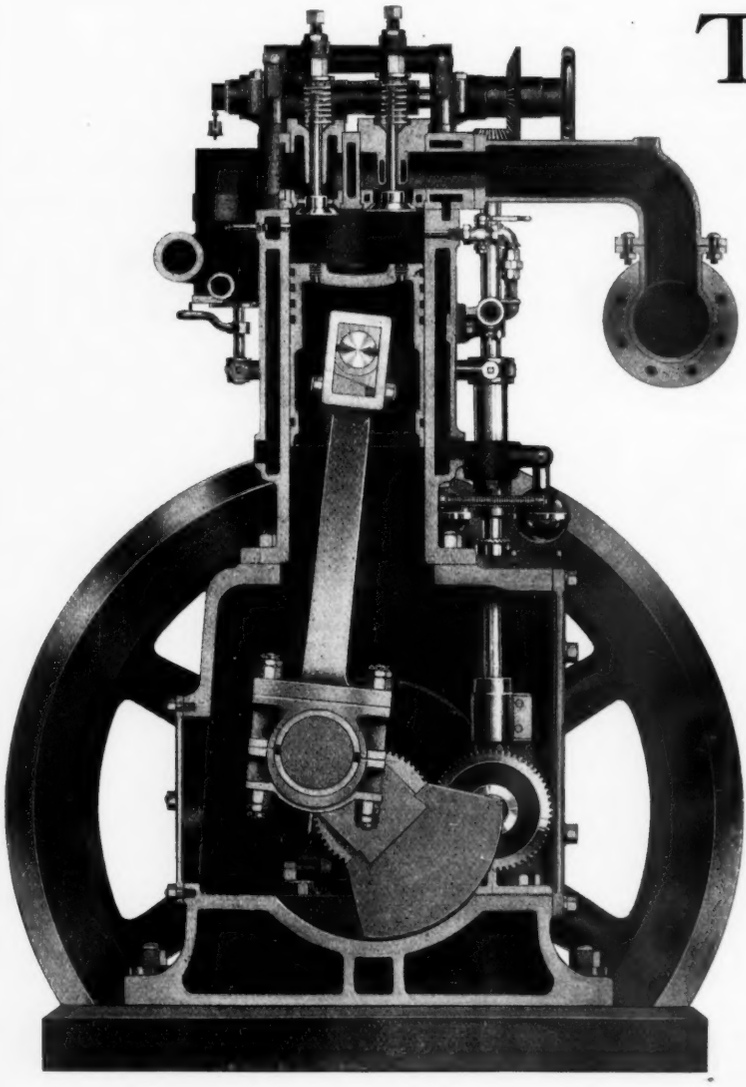
Gas Engines

To operate on Natural, Artificial or Producer Gas or Gasoline



Gas Producers

Using either Hard or Bituminous Coal, Coke, Wood, Peat or Lignite.



The Power That Pays

A Horse Power a whole year with fuel cost of only $6.00

A B-M-A Gas Engine and Gas Producer with the same expenditure of fuel will do on an average four times the amount of work done by an Economical Automatic cut-off Steam Engine.

We'll tell you how its done, in our Catalog.

The Bruce-Meriam-Abbott Company,

GAS ENGINE BUILDERS.

1700 Columbus Road,
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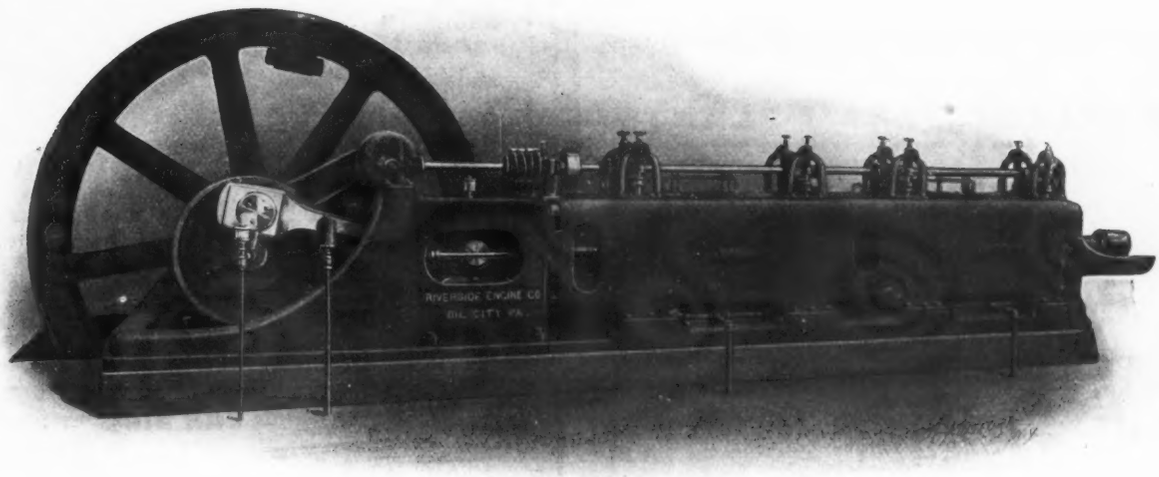

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HEAVY DUTY DOUBLE ACTING TANDEM GAS ENGINE

THE STANDARD AMERICAN GAS ENGINE

Built in all types, single cylinder single acting to twin tandem double acting, 40 to 2500 h.p.

Purely AMERICAN design and NOT a copy of any European engine, yet possessing MORE SUPERIOR FEATURES than any other engine built.

Gives as reliable service as a steam engine; this is proved by its record.

The most accessible engine on the market, yet particularly rigid and strong.

Has balanced water-cooled inlet and exhaust valves and the most reliable and flexible ignition system.

Runs 24 hours a day for months at a time.

Will operate satisfactorily on blast furnace, producer, coke oven or natural gas.

If you are contemplating the installation of gas power, let us show you the truth of all the above.

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COMPLETE STEAM PLANTS.

ESTABLISHED 1876.

61 OLIVER STREET,

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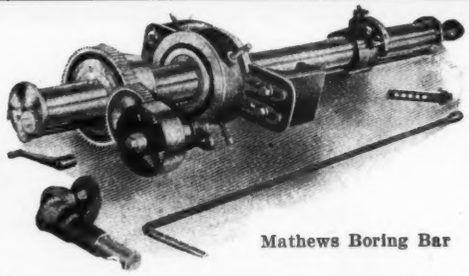
Pay Yourself For Reboring That Cylinder



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Why send it away and pay money to trucks, express companies and repair shops when you can do the work as well in less time with less inconvenience and at less cost? *Write for catalogue and prices.*

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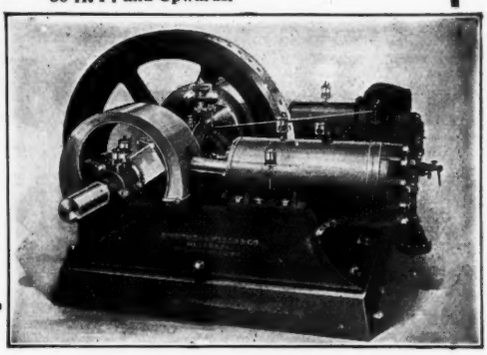
Single, Double and Multi-Cylinder Types.
30 H. P. and Upwards.

Adapted for all power purposes.
Economy and regulation fully guaranteed.



Struthers-Wells Co.,
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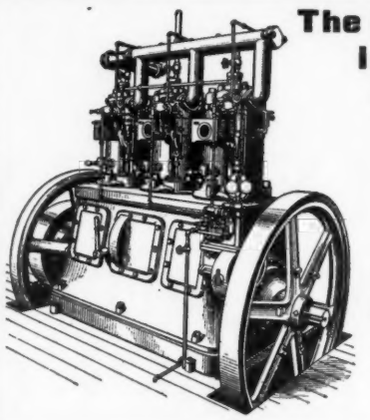

The most economical prime mover on earth.

Total fuel consumption and power costs guaranteed.

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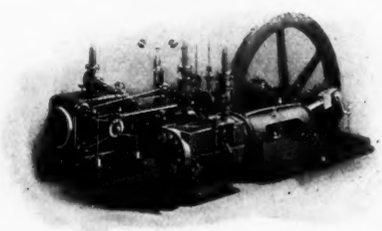

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Equipped with SAFETY Ammonia Compressors.
Operated by Simple and Compound Corliss.
Refrigerating Plants for all purposes.

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STATIONARY:
GAS, 75 to 2,500 H.P., Oil 3 to 250 H.P. MARINE OIL ENGINES, 3 to 25 H.P.

RELIABLE POWER AT LOWEST COST.

600 H.P. used in some of our shops.

OUR CUSTOMERS ARE MORE THAN SATISFIED.

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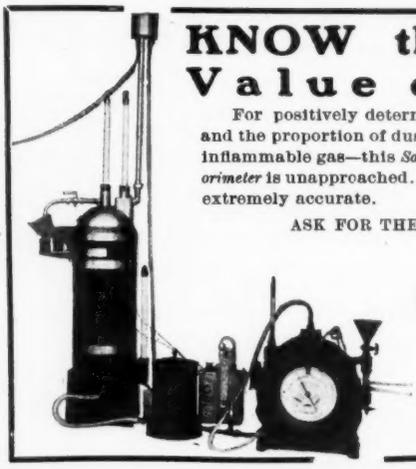

KNOW the Heat Value of Gas

For positively determining the heat value and the proportion of dust, tar and moisture in inflammable gas—this *Sargent Automatic Gas Colorimeter* is unapproached. A labor lightener and extremely accurate.

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best adapted to

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is that made by the

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Owned and built exclusively by the

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New York Office:
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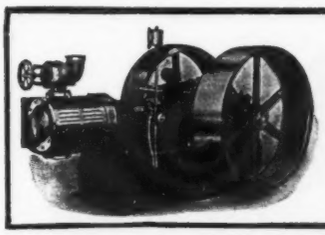

Skinner Engines are for those who want **maintained** economy and are willing to pay the price if they can be assured of profitable returns. We do not build cheap engines or engines that are economical **only** while they are new.

If you pay the engine man less you will pay the coal man more—and lots more.

Skinner Engine Company, Erie, Pa.

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WETHERILL Corliss Engines — **WILLIAMS** Vertical Engines — **FITCHBURG** Four Valve Engines — **HOUSTON, STANWOOD & GAMBLE** Slide Valve Engines

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Accurate Regulation for Electric Service—Automatic Cut-Off and Rites Fly-Wheel Governor.

A. H. ALBERGER COMPANY

45 to 600 H. P. Using Natural Gas
35 to 500 H. P. Using Producer Gas

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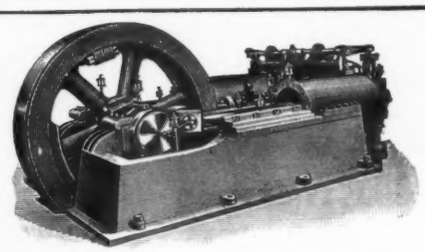
The Miller Gas Engine



is the result of ten years of practical experience in the design of gas engines for heavy duty. It is built in 35, 50, 75, 100, 150 and 250 H.P sizes. Among its unusual features is our patented system of vacuum governing, which gives a regulation only equaled by the steam engines. The many other good points of this most economical source of power are fully described in the catalog, which is sent on request.

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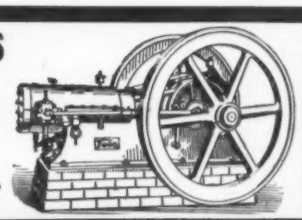
Furnish the most reliable power today and every day with the least cost, and trouble. Sizes 2 to 250 H. P. Catalog K on request.



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Warren's Pulley Cover

will render the surface of your pulleys firm and adhesive. The belt simply CAN'T slip. Increases power and keeps down expenses. Learn all about it from our Catalog.

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OTTO ENGINES

Are "Otto" Engines Dependable?

OTTO OTTO

Gentlemen:

As you will doubtless remember, two years ago last fall, we installed one of your 21-H.P. "Otto" Gasoline engines, and ran the same 103 days and nights without stopping. One year ago water was high and the engine was not run. Last fall water was again too low to enter our intake, and the engine and pump was started on November 2, 1906 and has run continuously for 3523 hours.

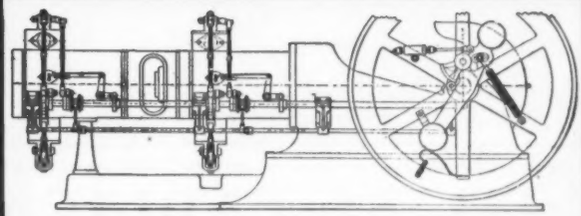
Is not this a good record?

Yours truly,
Bristol Aqueduct Co.

Bristol, N. H., 4-1-07.

OTTO GAS ENGINE WORKS, Phila., Pa.

STANDARD OF THE WORLD



This Automatic Cut-off Engine is the highest type of gas engine on the market today. For efficiency and regulation it is unsurpassed.

Write us your power requirements.

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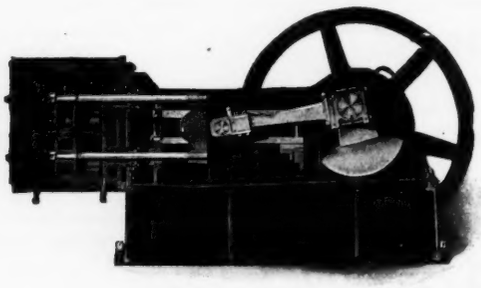

The American-Ball Duplex Compound

represents the highest development of high-speed engine building. It occupies no more floor space than a simple engine of the same power and assures 25 per cent. less steam consumption per horse-power-hour.

Both cylinders are cast in one piece, one cross head carries both piston rods, the connecting rod is of semi-marine type, very accessible for adjustment, and the valve gear is as simple as that of a simple engine.

Write for catalogue and lists of plants where American-Ball Engines—both simple and compound—may be seen in regular operation.

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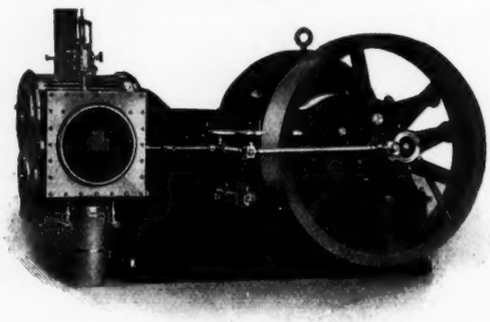
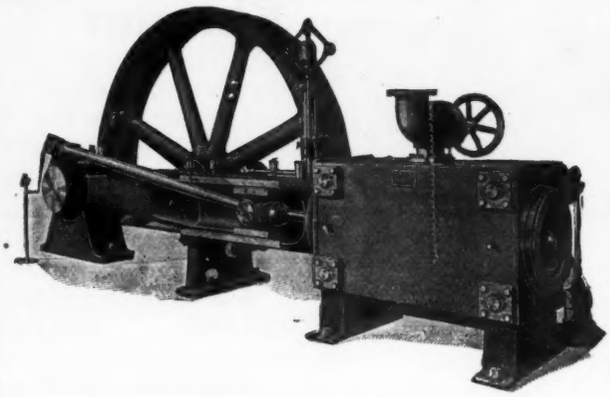




It's not good service now and then that counts in an Engine, but continuous good service. That is why

Harris-Corliss Engines

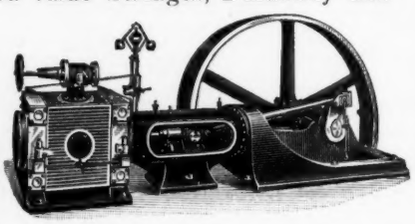
are being specified more and more in all progressive plants. Another point, the "Harris" is the *only* Engine, having the *"Brown" Patented Releasing Gear.* If you are interested in Engines in any way—it would be to your advantage to learn more about the *Harris-Corliss.* - - - *Write us.*

Wm. A. Harris Steam Engine Co., Providence, R. I.

THE OHIO CORLISS ENGINE

should be considered in your next Engine room lay out, if you value Strength, Durability and Economy—three most important essentials.

We've a Catalog for you.



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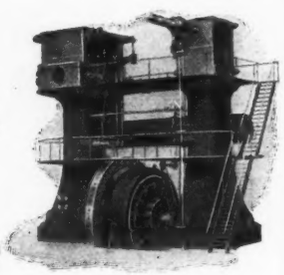
Established 1840. Zanesville, Ohio.

CORLISS AND Piston Valve Engines for Heavy Duty Service



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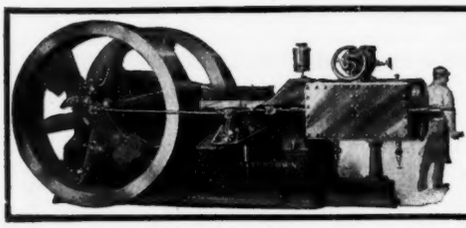

Good Engines for every power purpose. Ask for Catalog.

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Simple, condensing and compound, 50 H. P. to 2000 H. P. Complete steam power outfits for every service, Superior in workmanship and performance.

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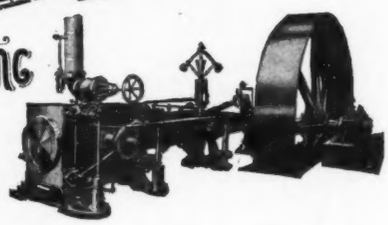
THE IMPROVED FISHKILL CORLISS ENGINE

BUILT BY THE FISHKILL LANDING MACHINE CO., FISHKILL ON HUDSON N.Y.



The most efficient and economical power for all purposes.

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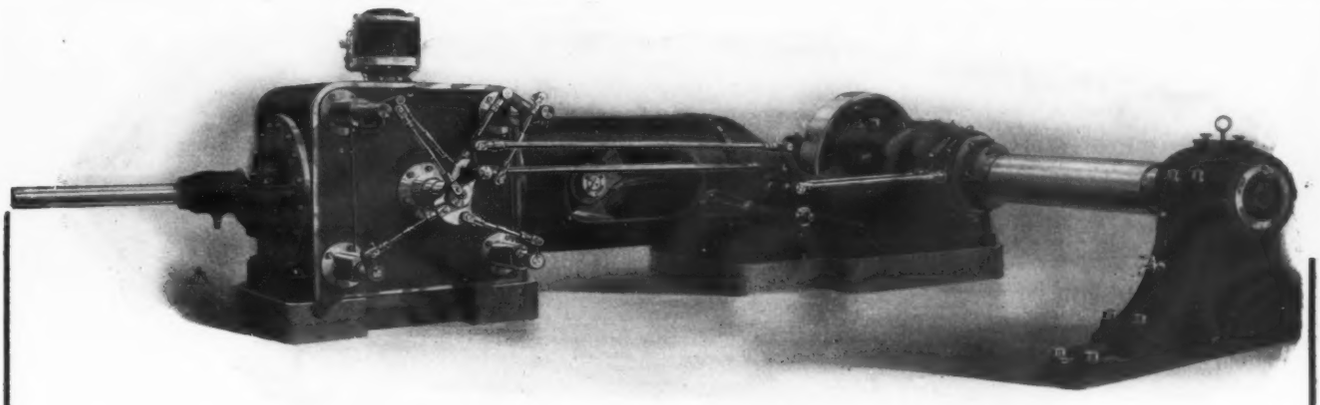
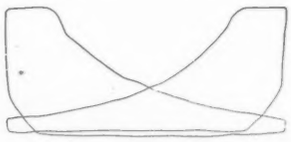


A Clark Corliss Engine Arranged For Direct Connection To Generator

Diameter of piston 26", stroke 36", revolutions 125, pressure 150 pounds, horse power at ¼ cut off 940, saving in cost of engine at power named over cost of standard Corliss type, delivering the same horse power at 80 revolutions, over $2000. Saving in cost of 600 K. W. generator at 125 revolutions, as against the same power unit at 80 revolutions, over $4000. Our engine record; 26 years in one plant, running 11 hours daily In all this time not an hour lost through breakdown or disarrangement of engine. We build this engine tandem or cross-compound and for speeds up to 200 revolutions per minute. Have them in service now at this speed. Design without a peer, endurance unequaled, economy the highest.



High Pressure Card at 200 revolutions per minute, Clark Compound Engine.

Let us tell you all about them. Catalog for the asking.

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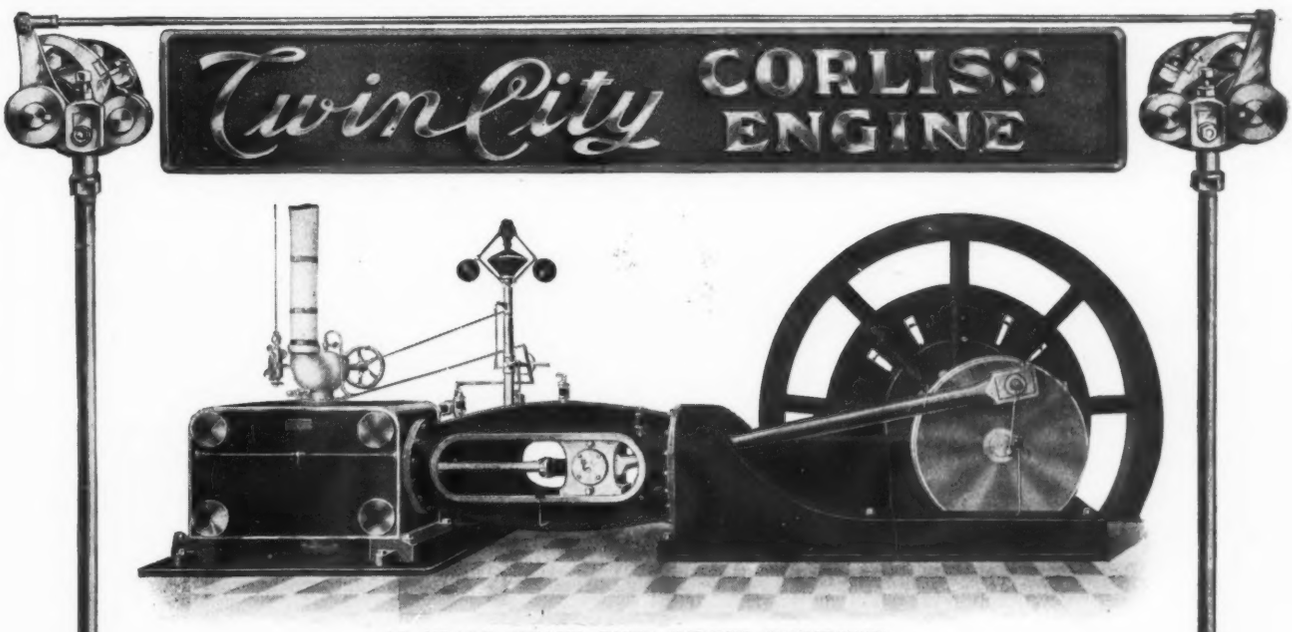

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We have built *Twin City* Corliss Engines for every kind of service from electric plants to heavy mill work and build them either direct connected to dynamo or belted to shaft, in either simple, cross or tandem compound, and they have always "made good." Send for our catalog "H."

MINNEAPOLIS STEEL & MACHINERY CO.

THE LARGEST MANUFACTURING PLANT IN THE WEST

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RICE & SARGENT ENGINES,

CORLISS TYPE.

Horizontal or Vertical, Condensing or Non-Condensing, Simple Cross Compound or Tandem. Designed for Heavy Service of all Kinds. sizes 100 H.P. to 7500 H.P. Releasing Gear Engines up to 1000 H.P. at 150 R.P.M.

FOR HIGHER SPEEDS USE OUR

Four Valve Non-Releasing Corliss Engines,

Speeds up to 250 R.P.M.

ALL DESIGNED AND BUILT BY

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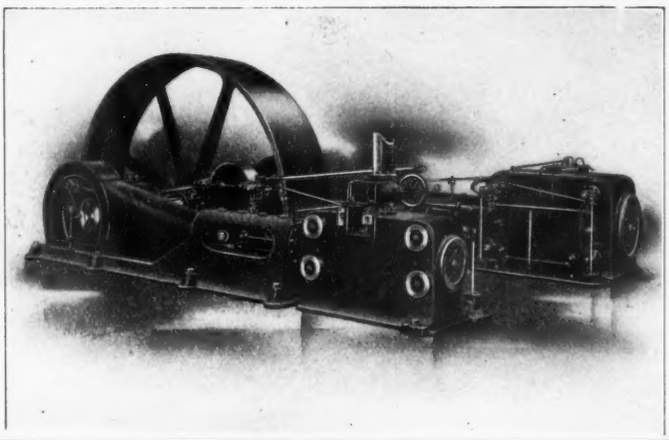

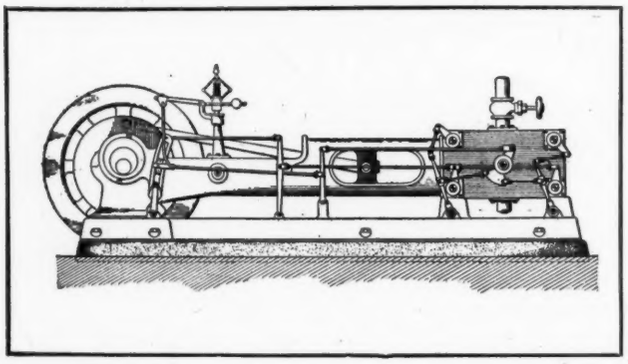

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The patent has for its object the positive operation of a Corliss Valve Gear, obtaining all the advantages of speeds unattainable with detachable gears, with all the efficiency of a four-valve distribution.
See the possibilities? The engine is in active operation today giving big results under all tests. Size of cylinder 8" x 16". Engine and patent are BOTH FOR SALE. Space does not permit a detailed description, but same will be sent to any one interested. If you want to control a PROVEN success, just show your interest by writing.

GEORGE MARSHALL,

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CORLISS ENGINES.

Simple, Tandem and Cross Compound

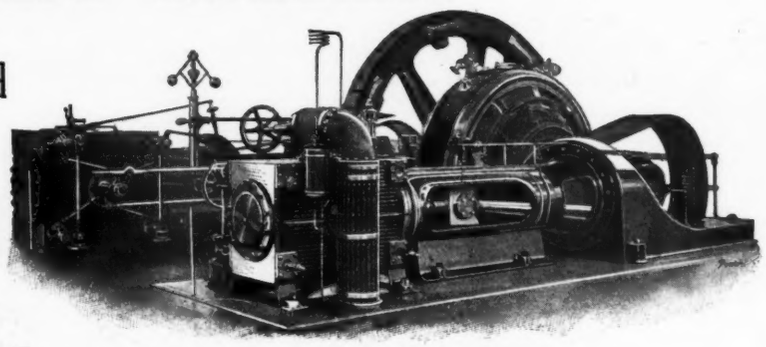
From 50 to 3000 H. P.

Heavy Duty or Girder Frame.

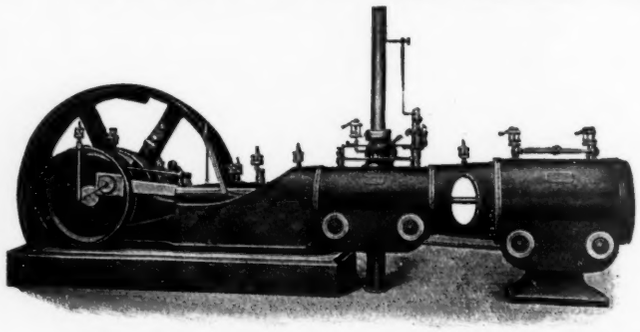
ST. LOUIS IRON and MACHINE WORKS,

Main Office and Works, St. Louis, Mo.

New York Office, 135 Broadway.



"RUSSELL ENGINES"



Four Valve Semi-Corliss—Single Valve Enclosed Self-Oiling and Open Types, Simple and Compound, Belted or Direct Connected, Designed Specially for heavy duty, economy and close regulation.

The Russell Engine Co.,

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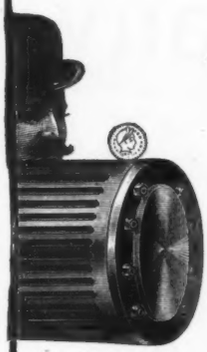

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Balance A Dollar

on the cylinder of the

Ideal Engine

while she is pulling a load at high speed. She runs in oil, using her lubricants over and over.

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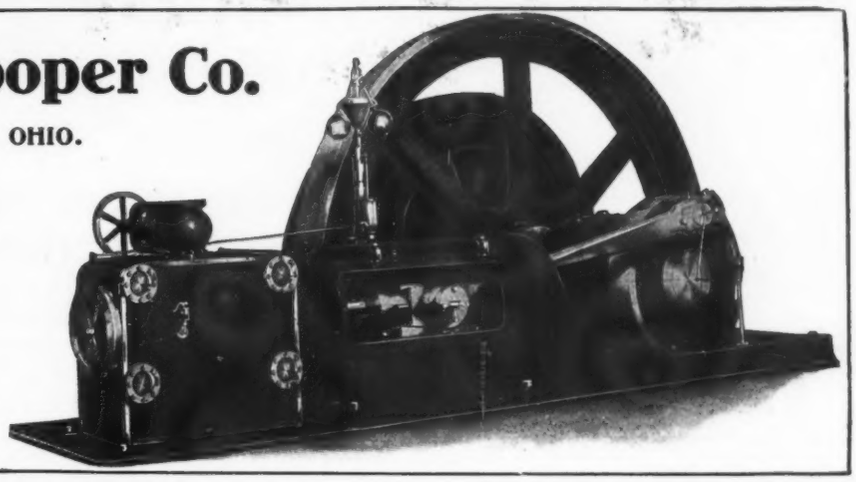

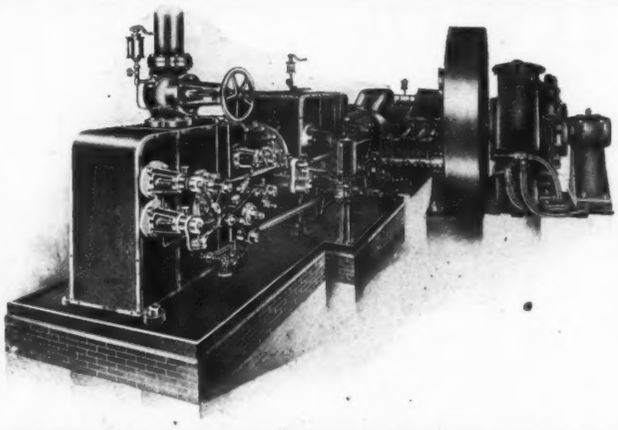

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ST. LOUIS, MO., U.S.A.

Builders of Corliss Engines,
Horizontal and Vertical,
Simple or Compound,
Tandem or Cross,
From 30 to 5000 H.P.
Highest Economy of Steam.

Philadelphia Office, 509 Mutual Life Bldg., Mr. Geo. H. Connor, Manager.

THE BROWNELL CO.,

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Manufacturers of

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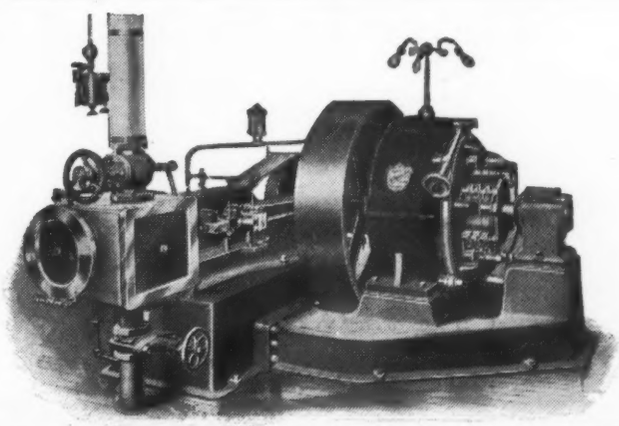

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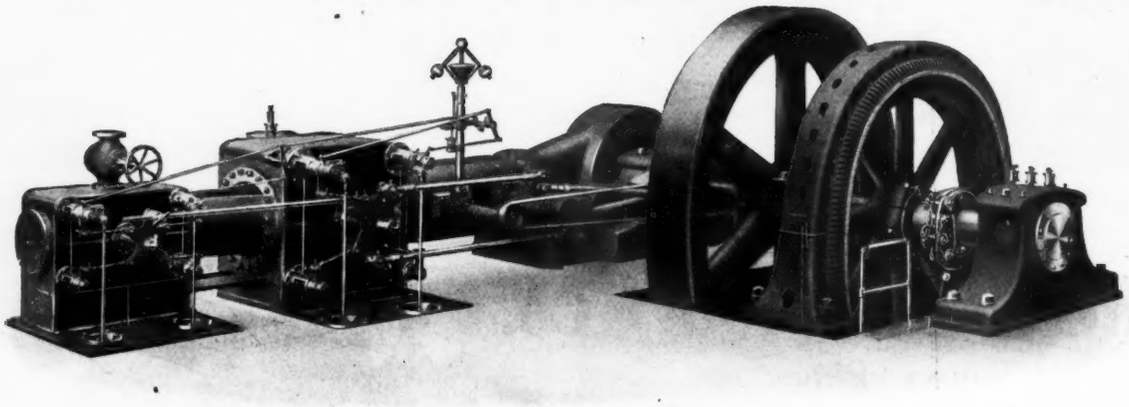
All Sizes **CORLISS ENGINES** For All Services



Heavy Duty Tandem Compound Engine d. c. to Alternating Current Generator.
Complete unit built by Allis-Chalmers Co.

Steam Turbines—Hydraulic Turbines—Gas Engines

With Generators Especially Designed for Connection to Them and Electrical Apparatus of Every Kind for Direct and Alternating Current.

General Offices, Milwaukee, Wisconsin, U. S. A.

If It's Ballwood Built

There Is Nothing Better

Like a watch for accuracy, a machine gun for strength and speed.

The Ballwood is above consideration of cost, as the fuel saving alone will pay for it over and over.

It requires less attention than any other engine of its horse power.

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Makers of Ballwood Welded Flanges.

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It's Performance, Not Promise, That Sells Fitchburg Engines

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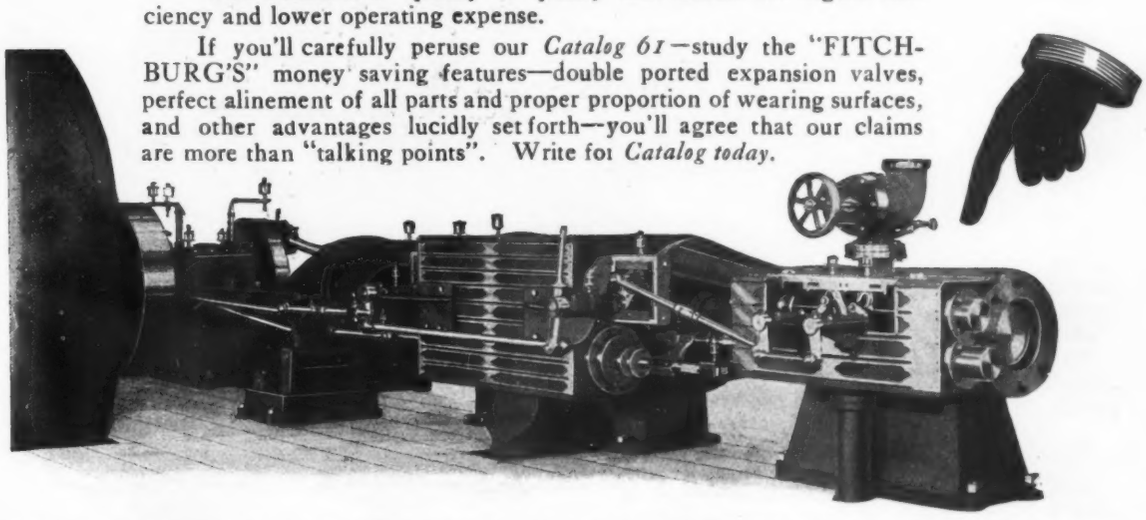
"FITCHBURG" quality is quality that counts for higher efficiency and lower operating expense.

If you'll carefully peruse our *Catalog 61*—study the "FITCHBURG'S" money saving features—double ported expansion valves, perfect alinement of all parts and proper proportion of wearing surfaces, and other advantages lucidly set forth—you'll agree that our claims are more than "talking points". Write for *Catalog today.*



THE FITCHBURG STEAM ENGINE COMPANY, FITCHBURG, MASS.

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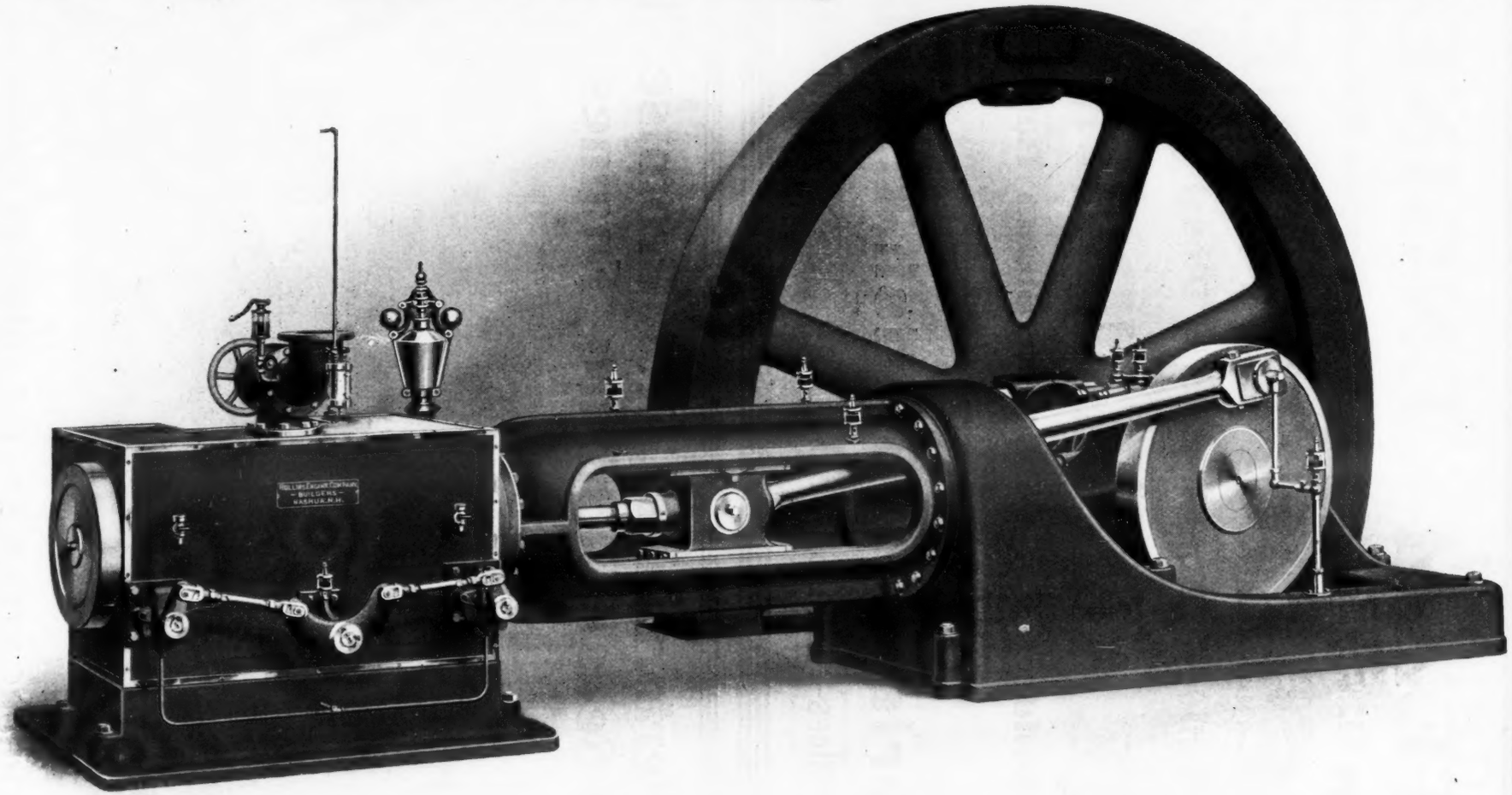
The Rollins Heavy Duty Engine For Heavy Profits



The Rollins embraces the best and most advanced ideas in modern engine building. Strength, power and stability are evident in every line. Its installation marks a new era in higher efficiency and freedom from trouble forever. Send for Bulletin No. 15.

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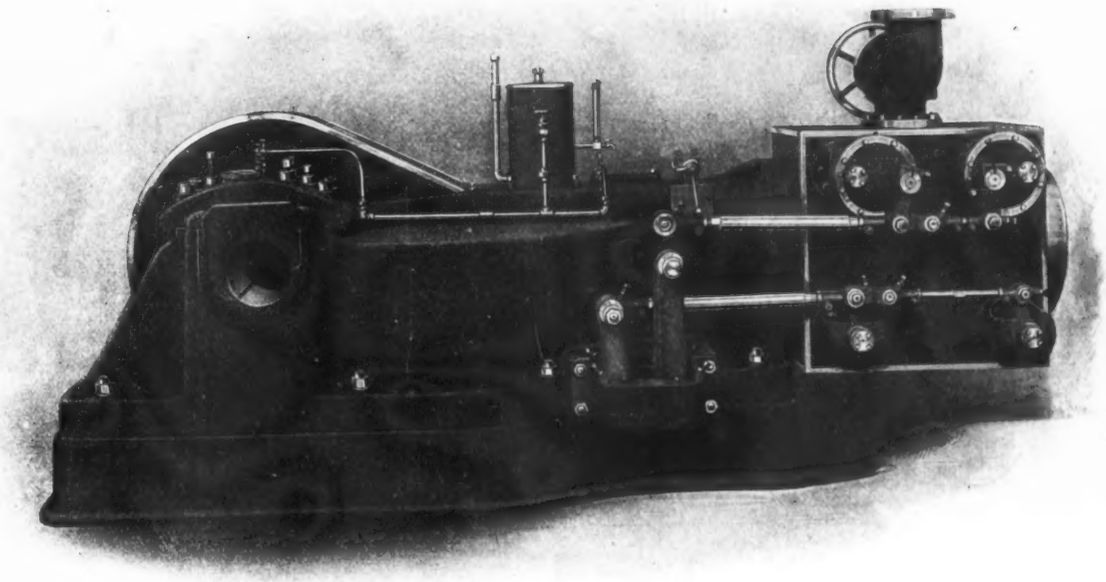

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Reliable and Economical

Under Average and Usual Conditions as the

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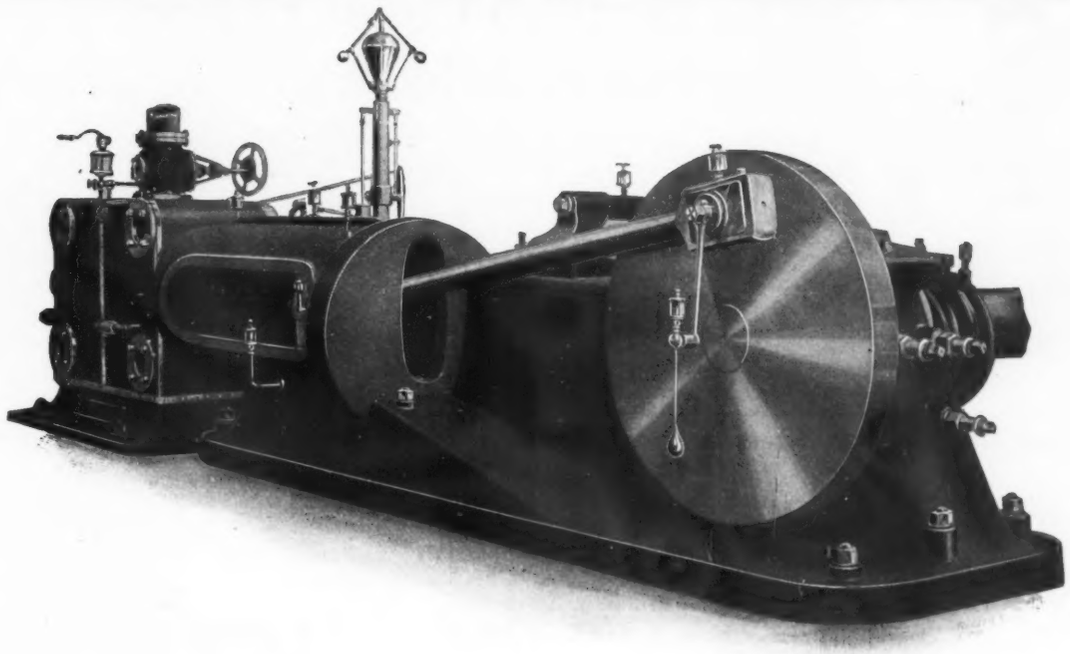

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for strength, durability, speed and perfect regulation—in short, the

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is as good as it looks and it's the beauty of all engines.

We plan and contract for Complete Steam Power Plants and maintain a talented, experienced and thoroughly practical engineering corps that is at the service of our customers.

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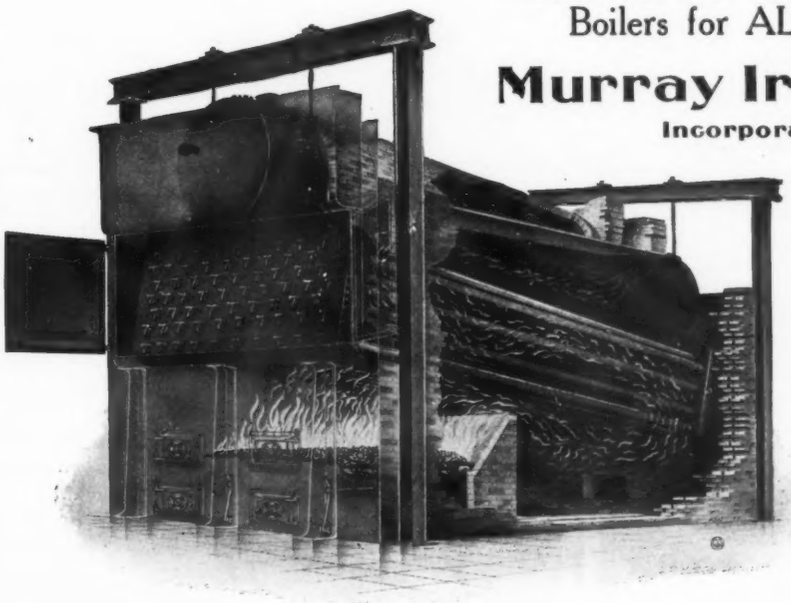

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Incorporated Feb. 1st, 1870

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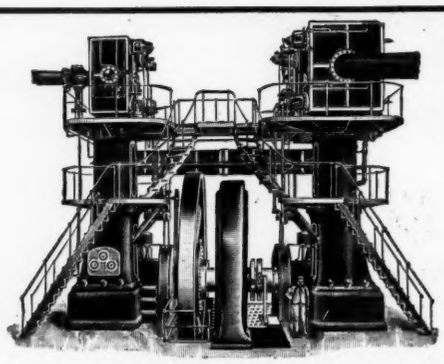

Hamilton-Corliss Engines
Hamilton-Holzwarth Steam Turbines

for all purposes.

Send for Catalog T of Turbines.
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Greater Steam Economy

results wherever the DAKE STEAM TURBINE is used, because of its nozzle and bucket construction, governing mechanism and other features, solely "DAKE-AMERICAN." May be run direct-connected or by belt drive.

Let us talk over the Turbine question together. Ask for our Catalog when writing.

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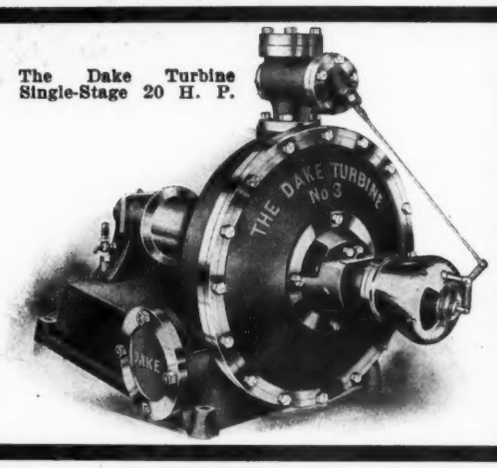
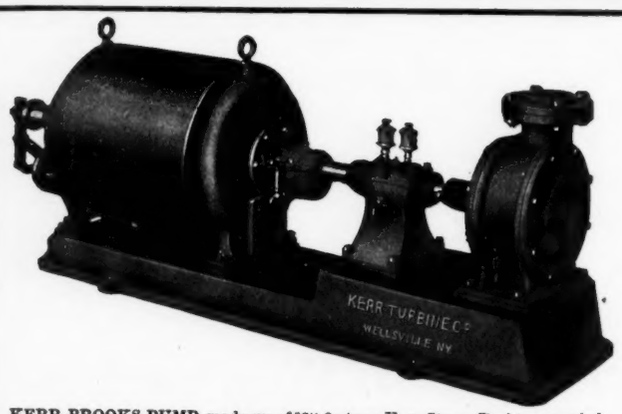
The Dake Turbine
Single-Stage 20 H. P.





KERR-BROOKS PUMP, made up of 12" 6-stage Kerr Steam Turbine coupled to 4" Type "C" Brooks Pump. Capacity 500 g. p. m. Heads 40-120' Speeds 1400-2430 r. p. m.

Quick Delivery. Variable Speed.

TURBINE PUMPS for water works, condensers and boilers. Require less steam, attention, oil and space than direct acting piston pumps. Capacity 125 to 4000 g. p. m. Head 40 to 120 ft.

TURBINE GENERATORS. Direct current 2 kw. to 200 kw. standard voltages. Alternating current 25 to 250 k. v. a., 60 cycle, standard voltages to 2200. Regulation close.

TURBINE BLOWERS for gas works, foundries and forge shops. No belts or reducing gears. Started and stopped quickly. Capacity up to 100,000 cu. ft. per minute. Pressures up to 16 ozs. NO OIL IN THE EXHAUST STEAM.

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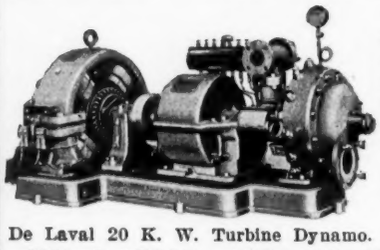

Steam Turbine Motors
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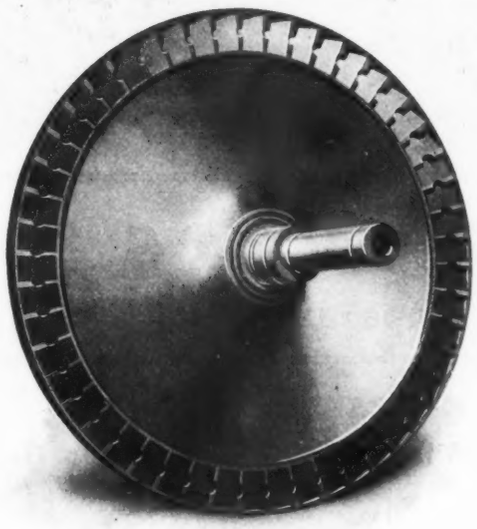
During the first six months of this year. Ten men were killed and the property lost was nearly $1,000,000. THE LOCKE ENGINE STOP would have prevented anyone of these. It has proved itself to be the only reliable device of its kind that has prevented accident after accident without failure. There has never been a fly wheel explosion where there was a LOCKE ENGINE STOP. Remember, no chains, no sprockets, no sticking of throttle valve. Send for catalog "K" showing installations

Locke Regulator Co., Salem, Mass., U. S. A.



The Sturtevant Steam Turbine

Is more simple, more durable, and of less weight than any other turbine built in this country.

Indestructible buckets and low speed are special features.

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Designers and Builders of Heating, Ventilating, Drying and Mechanical Draft Apparatus; Fan Blowers and Exhausters, Rotary Blowers and Exhausters; Steam Engines, Electric Motors and Generating Sets; Pneumatic Separators, Fuel Economizers, Forges, Exhaust Heads, Steam Traps, Steam Turbines, etc. 642

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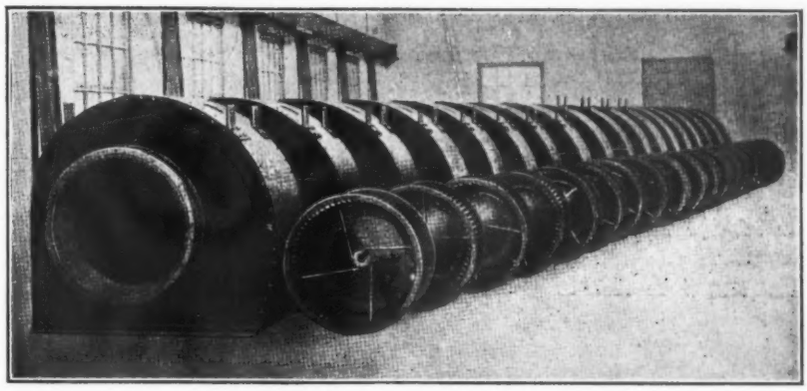
The Modern "Turbine" Blowers.

SAVE SPACE — SAVE WEIGHT — SAVE POWER



USED ON THE STEAMSHIP

"LUSITANIA"

and extensively in use in Steamships, Powerhouses, Mills, Factories, Industrial and Public Buildings all over the world.

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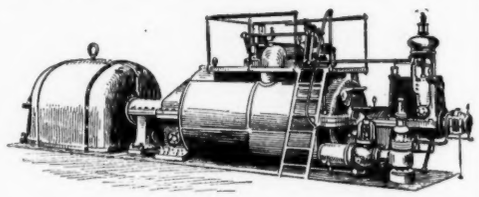
Prime Movers

and Auxiliary Apparatus

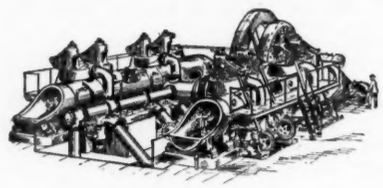


Steam Turbines

Over a Million H. P. Built and on Order

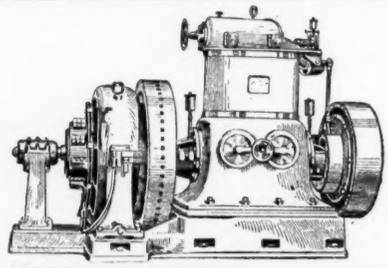
CHEAPER THAN STEAM ENGINES { to buy, to install, to operate, to repair }

REQUIRE { less oil, less fuel, less attention, less space }



Heavy Duty Gas Engines

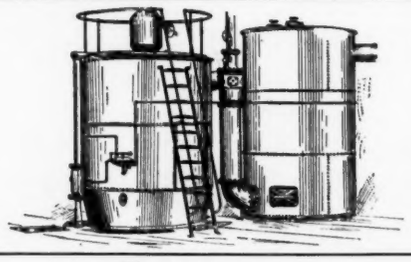
IN DAILY OPERATION { Electric Railway Service. Central Station Service. Blast Furnace Service. Steel Works Power Service. Industrial Power Service. }



Single-Acting Steam Engines

5 to 400 H. P. Capacity

Best engines for continuous service.
Built for steam pressures up to 200 lbs.
Economy sustained at all loads.
Durability unquestioned.



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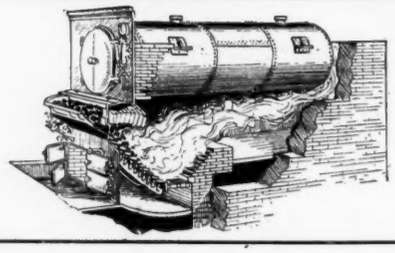
Controlled automatically. No gas holder required. No grates to burn out. Ashes removed without interference with the delivery of gas. Gas suitable for heating, as well as for gas engines.



The Roney Stoker

Over 1¼ million boiler h.p. in daily service. Can be installed under all types of boilers. Will operate on all kinds of coal. Insures smokeless combustion.

The Westinghouse Machine Co.

Designers and Builders of Steam Turbines, Steam Engines, Gas Engines, Gas Producers and The Roney Stoker.

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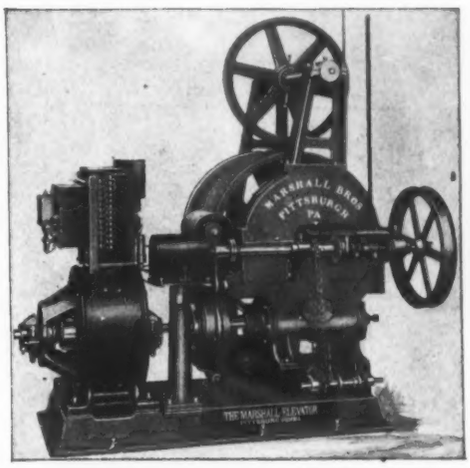
Motor=Drive

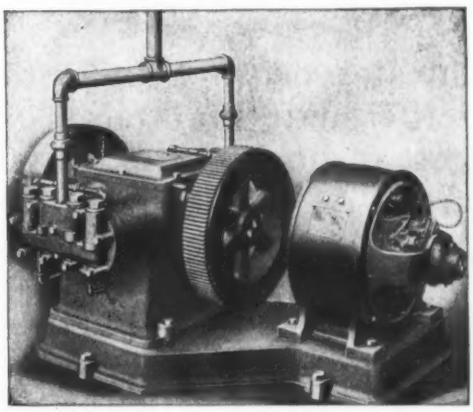
Westinghouse Motor-Drive is the best example of efficient and economical electric power application.

There is a Westinghouse Motor made to drive anything, anywhere, any time or all the time, under any conditions.

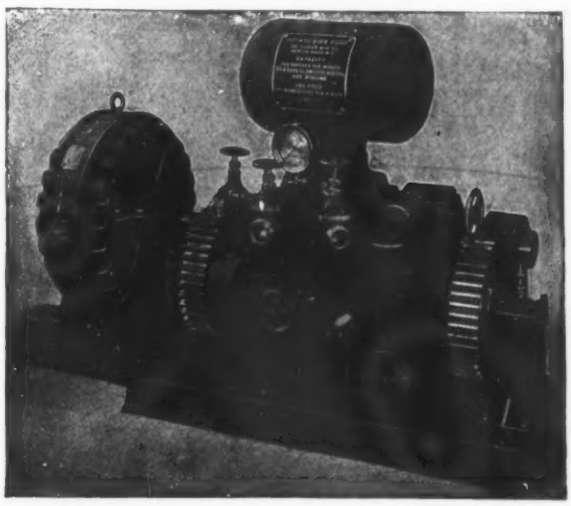
If you have a power problem to solve, consult our experts, their services are at your disposal.



Westinghouse Motor Driving Marshall Bros. Electric Elevator Hoist.



Westinghouse Motor Driving Chicago Pneumatic Tool Co. Compressor.



Goulds Rotary Pump Driven by a Westinghouse Motor.

Westinghouse Electric & Mfg. Company,

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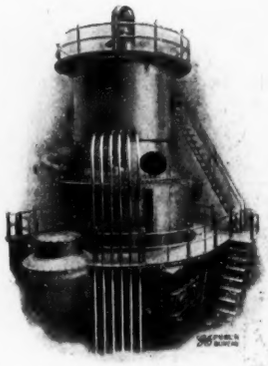


THE CURTIS STEAM TURBINE is an American product, invented, developed and built in this country. Its superior design and construction make it the most advanced type of steam turbine. The VERTICAL SHAFT contributes distinct advantages to large Curtis Turbine Generators.

The foundation is small in size, small in cost and extremely simple in construction.

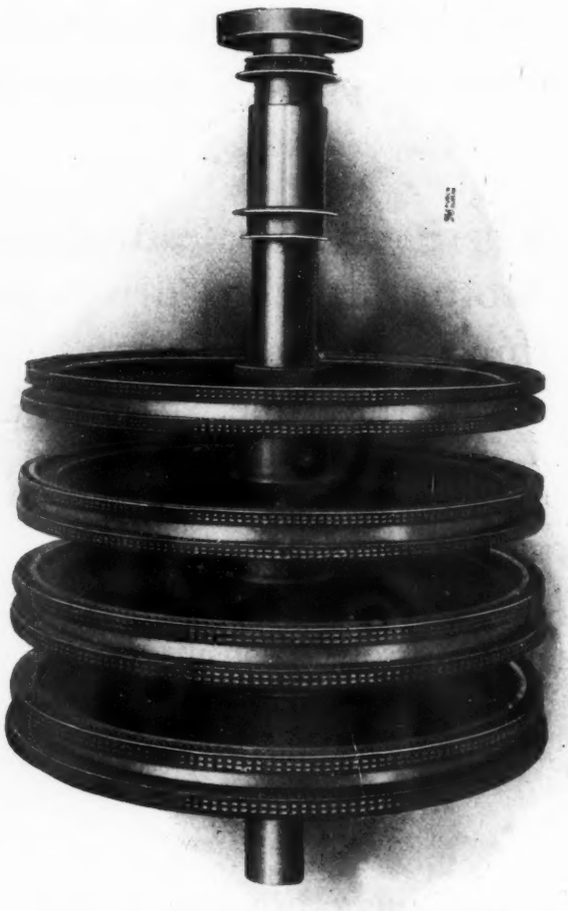
The step bearing under the end of the shaft maintains exactly proper position of revolving part.

The shaft is free from all deflection and bending strains.

The shaft bearings carry no weight, serving simply as guides.

The complete revolving element has the same features of solid simplicity as the ordinary boy's spinning top.

Further features illustrated in new turbine Catalog 561-D sent power plant engineers.



Rotating Wheels of Vertical Curtis Turbine

1516

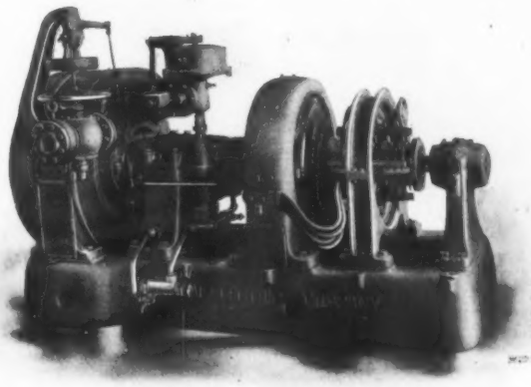
New York Office, 44 Broad Street. **Principal Office, Schenectady, N.Y.** **Sales Offices in all large cities.**

General Electric Company

HORIZONTAL CURTIS STEAM TURBINES follow the simple lines of construction of the large vertical shaft turbines.

The shaft is short, of small diameter and low surface speed, resulting in low bearing friction and small tendency to wear.

A direct result of this simplicity is the assurance of uninterrupted service and a small cost of maintenance.



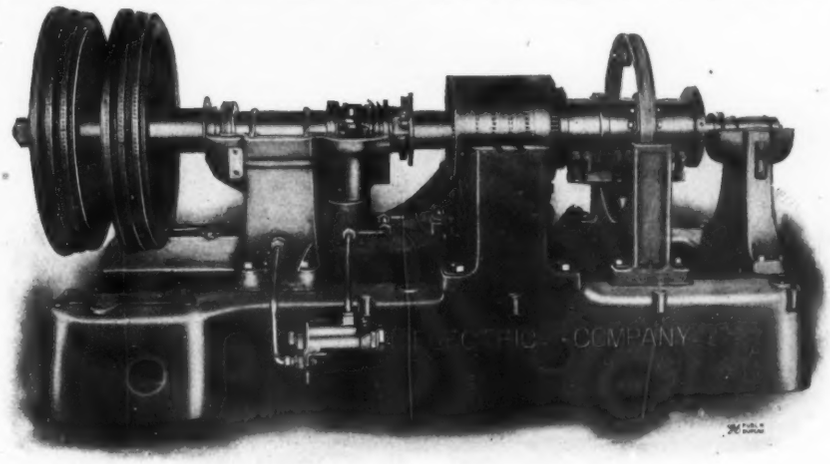
100 K.W. Curtis Turbine Connected to Direct-Current Generator

Foundations are moderate in size, due to the light weight and absence of reciprocating parts. Floor space required is less than in any type of horizontal engine and the height is much less than that of vertical engines.

Generators are of improved design with commutating poles and special commutator construction, giving sparkless commutation at all loads.

The entire design embodies the simplicity of a water-wheel.

The use of a simple and reliable governor results in excellent regulation, an independent emergency governor insures absolute safety at all times.



100 K.W. Curtis Turbine and Direct-Current Generator, Partly Assembled, Showing Generator and Turbine on the Shaft.

Made in sizes from 20 to 300 K.W. for direct current and in several sizes for alternating current.

Those interested will be glad to receive Catalog 562-D. Sent on request.

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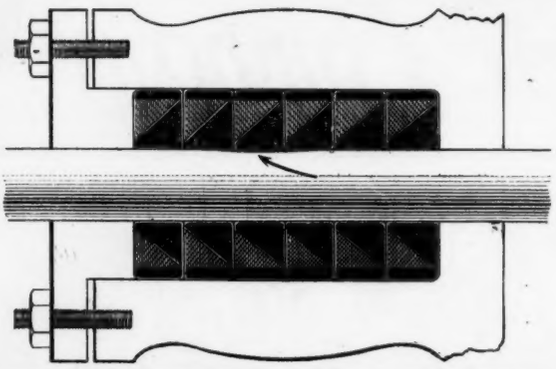
New York Office, 44 Broad Street. **Principal Office, Schenectady, N.Y.** Sales Offices in all large cities.



"Combination"

(Trade Mark Registered.)

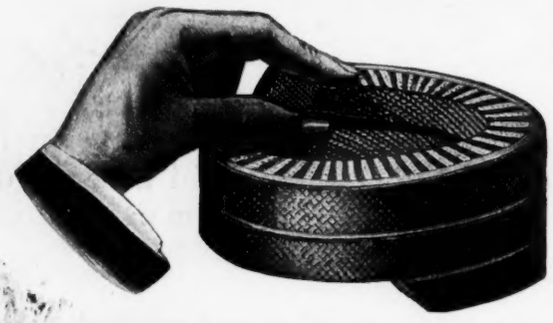
The 50 Per Cent. BetterPacking

needs less attention, less renewing, and holds tighter than any other made. Repacking consists simply in SCREWING IT UP FINGER TIGHT. Note its construction of soft flax on rod, Tucks packing, and rubber packing, giving extreme strength, durability and elasticity.

"RUBBERBESTOS" SPIRAL

(Trade Mark Reg.)

is built on the wedge principle thus compensating for frictional wear of rod by slight tightenings. Expansion is DIRECTLY ON THE ROD instead of on the gland.



"RUBBERBESTOS" SHEET PACKING.

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is the Standard for *high pressure* service. It is made of *asbestos* and *rubber* vulcanized at such a high degree of heat that the heat of the joint cannot affect it. It resists heat and pressure perfectly.

Can You Afford to Take Anything Less than the BEST?

Trade Mark "Metalbestos" Registered For High Pressure

has a "Rubberbestos" core, giving elasticity, which is covered with Asbestos to protect the core from heat, and *Soft Metallic Wire* to insure durability. It is the only packing for *Marine* or *Power Station* work.

Patented.

RUBBERBESTOS SECTIONAL GASKET

Any size gasket can instantly be made which will stand up under *any pressure* on account of the *wire* or *metal* centers. The *"Rubberbestos"* covering makes them last and the improved coupling *prevents ends* from *separating*. They are by far the most durable and convenient you can use.

Ask for and take only the genuine,

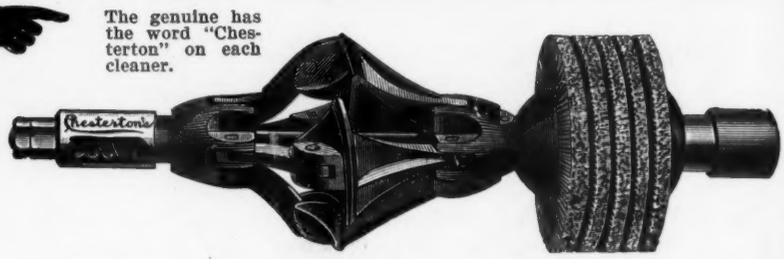
"COMBINATION"

(Trade Mark Registered.)

SCRAPER AND BRUSH

Is actually two tools for the price of one. The scraper cleans out the scale perfectly and the brush, following, brushes the tubes absolutely clean. This is done at one operation.

The genuine has the word "Chesterton" on each cleaner.



A. W. CHESTERTON & COMPANY,

Or ADVANCE PACKING & SUPPLY CO., 123 Franklin St., Chicago, Ill.

No. 64 India St., Boston, Mass., U. S. A.